Electronic Control and Protection System CET 4

User Manual

Rockwell Automation

Important User Information

Because of the variety of uses for the products described in this publication, those responsible for the application and use of this control equipment must satisfy themselves that all necessary steps have been taken to assure that each application and use meets all performance and safety requirements, including any applicable laws, regulations, codes and standards.

The illustrations, charts, sample programs, and layout examples shown in this guide are intended solely for purposes of example. Since there are many variables and requirements associated with any particular installation,

Rockwell Automation does not assume responsibility or liability (to include intellectual property liability) for actual use based upon the examples shown in this publication.
Rockwell Automation publication SGI-1.1, *Safety Guidelines for the Application, Installation, and Maintenance of Solid-State Control* (available from your local Rockwell Automation office), describes some important differences between solid-state equipment and electromechanical devices that should be taken into consideration when applying products such as those described in this publication.

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Throughout this manual we use notes to make you aware of safety considerations:

ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage or economic loss.

Attention statements help you to:

- identify a hazard
- avoid the hazard
- recognize the consequences

Important: Identifies information that is critical for successful application and understanding of the product.

Attention !

Rockwell Automation reserve the right to adapt the products described in this manual at any time to suit latest technical developments. Accordingly the attached information is not object of the contract and may change without you being notified beforehand.

Prerequisite for impeccable operation is correct transport, proper and competent storage and installation, as well as careful operation and maintenance.

1. The power supply must be switched off prior to any intervention in the electrical or mechanical part of the equipment!
2. In accordance with the applicable rules, work on electrical equipment or means of production may only be carried out by competent electricians or suitably trained persons guided and supervised by a competent electrician.
3. The electrical equipment of a machine / plant must be inspected / tested. Deficiencies such as loose connections or scorched cables must be eliminated immediately.

4. The discribed control- and protection system CET 4 features supervision and protection functions which can switch the devices of automatically and thereby bring motors to standstill. Motors can be brought to standstill also by mechanical blockage. Furthermore, mains failures and voltage fluctuations can also cause switching off.
5. In case of fuctional disturbances the machine / plant must be switched off and protected immediately! The elimination of disturbances must be organized without delay!
6. The elimination of a disturbance may cause the motor to start running again by itself. This may endanger persons or damage equipment. The user is obliged to take the necessary safety measures against this type of occurrence so that any danger is precluded.
7. Sufficient safety distance to the CET 4 must be maintained where wireless equipment (walkie-talkies, cordless and mobile phones) is used.

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1.1 Overview

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1.2 Why Have an Electronic Control and Protection System?

The need to optimize production facilities requires enhanced control, monitoring, and protection systems.

On the one hand, motors and installations must be utilized to a maximum; on the other, idle times required for maintenance and caused by motor failures must be minimized. Such stringent demands are ideally satisfied by the microprocessor-based CET 4 control and protection system.

The CET 4 has a modular design and is easily programmed. Its attributes enable an optimum fit to a wide variety of motor and installation requirements.

The CET 4 provides continuous monitoring of motor operating data in either of two ways. The data can be viewed directly on the CET 4, or it can be monitored remotely via a network, utilizing a PC or process computer. Likewise, the main statistical data can be accessed at any time.

Figure 1.1 CET 4

1.3 Operational Demands of the Motor/Drive

1.3.1 Temperature Rise

Motor designs and applicable standards require that when a motor is operated under specified loads and ambient conditions, the critical parts of the motor will remain within an allowable temperature range, and short-term overloads will not harm the motor.

The device protecting the motor must permit full utilization of the motor and therefore its economical operation. At the same time, the protective device must switch off rapidly if an overload occurs.

1.3.2 Motor Operating Characteristics

Electric motors absorb electrical energy and supply mechanical energy. During this energy conversion, losses are produced in the form of heat. The total loss comprises the following separate losses:

- Losses independent of the current
  - Iron losses caused by remagnetization and eddy currents
  - Mechanical losses caused by friction and ventilation

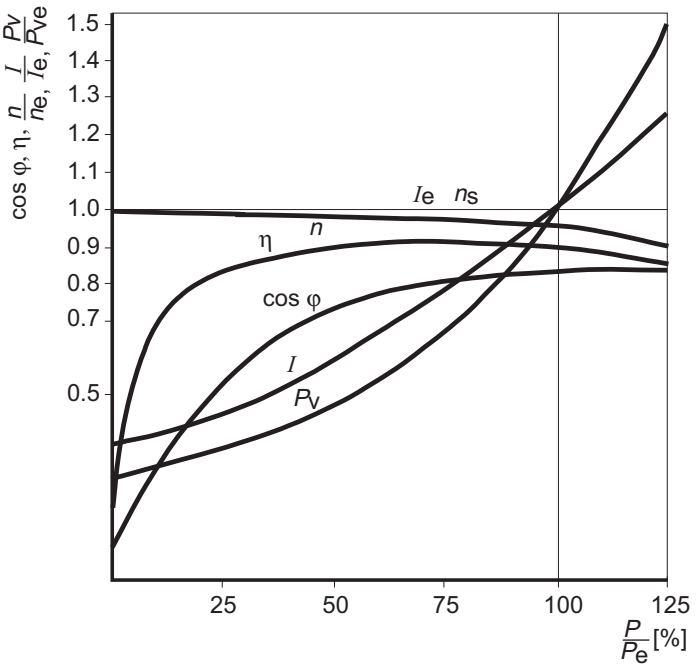
These losses are virtually constant, i.e., they also occur at no load.

- Losses dependent on the current
  - -Heat losses caused by the current in the stator
  - -Heat losses caused by the current in the rotor

These losses increase with load, i.e., with the current consumed by the motor.

- Increased temperature rise caused by poor cooling
  - -Cooling fins are dusty or damaged
  - -Coolant temperature is too high

Figure 1.2



P	Power
Pe	Rated operational power
Pv	Power losses
Pve	Power losses under rated conditions
I	Operational current
I_e	Rated service current
n	Speed
n_e	Rated operational speed
n_s	Synchronous speed
cos φ	Power factor
η	Efficiency

Operating characteristics of an AC motor as a function of load. Between no load and half load, the losses increase only slightly with rising load. Between half load and rated load, the change in efficiency is minimal, and the power factor approaches its maximum. The losses increase approximately proportional to the load. Above rated load, the losses increase more rapidly than the load.

1.3.3 Current and Temperature Curves

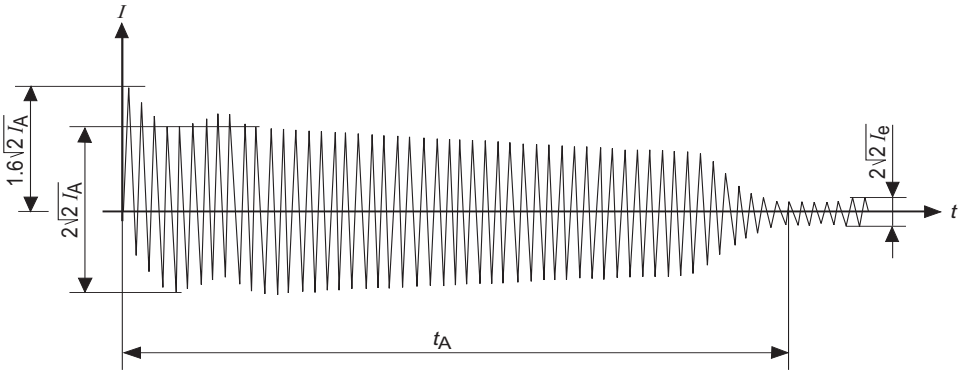
The power losses are approximately proportional to the square of the motor current. The potential for motor hazards exists mainly during starting and during locked rotor condition. With locked rotor, the maximum value of the starting current flows (approximately 4 ... 8 times rated service current, I_e), and all the power absorbed is converted

into heat. As the motor speed increases, the power converted into heat decreases. But if the rotor remains locked, the temperature of the stator and rotor windings rises considerably, specifically caused by the high losses and the short time that heat can flow into the laminated core. If the motor is not switched off quickly, the stator or rotor winding can burn out.

After start-up, the temperature of the winding rises according to the load and cooling of the motor. In time, the winding reaches its steady-state value.
A high current results in a correspondingly high operating temperature.

Figure 1.3

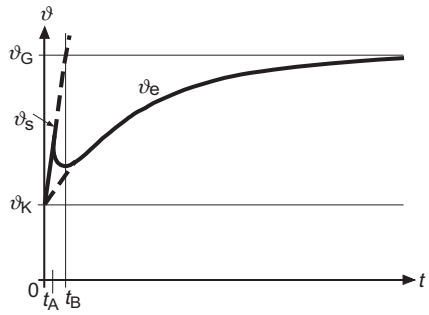
I_A Starting current
t_A Starting time
I_e Rated service current
t Time



Oscillogram of switching on a cage induction motor by direct-on-line starting. The high motor starting current I_A flows during the starting time (t_A). If this is less than the limit specified by the manufacturer (usually 10 sec.), the starting current does not cause any excessive temperature rise. The brief, asymmetrical peak when switching on can be ignored.

Motors are not thermally homogeneous. The winding, stator iron, and rotor have different heat capacities and conductivities. Following unduly heavy loads, e.g., during starting, temperature equalization occurs between the various parts of the machine. Most importantly, heat flows from the warmer winding into the cooler iron until the temperature difference is minimal.

Figure 1.4



ϑ_G Temperature limit of the insulation
ϑ_K Coolant temperature
ϑ_s Temperature rise at start
ϑ_e Temperature rise when operated continuously at rated current
t_A Starting time
t_B Permitted stalling time

Temperature rise in a motor winding. During the starting time (t_A), the temperature of the winding rises very rapidly; at the end of start-up, the temperature drops temporarily because heat is transferred to the laminated core.

1.3.4 Limiting Temperatures, Insulation Classes

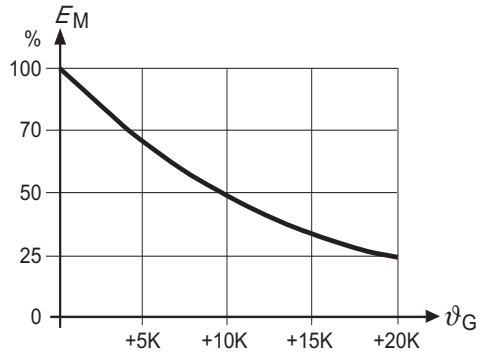
The permissible temperature limit for a winding – and thus the load-bearing – capacity of the motor is primarily a function of the motor's insulation. Applicable standards (UL, CSA, IEC, and NEMA) distinguish between different classes of insulation and corresponding temperature limits.

1.3.4.1 Insulation Aging

The aging of insulation material is a chemical process that is accelerated by continuous overtemperature. It may be assumed that a winding temperature that is constantly 10 K higher than the temperature limit reduces the motor life by half. This "life law" shows that particular attention must be paid to adhering to the permitted operating temperature for long periods of time. (Note that overtemperatures of short duration and infrequent occurence do not seriously affect the life of the machine.)

The CET 4's ability to accurately limit excessive current conditions greatly aids in extending motor life. In practice, it may be expected that there will be reduced loads and pauses, so that when the temperature limit is reached, the life will not be impaired.

Figure 1.5 Reduction in Average Life (E_M) of a Motor When Winding is Continuously Overheated



E_M Average motor life

ϑ_G Temperature limit of the insulation

1.3.4.2 Rotor Temperature

The rotors of cage induction motors with simple construction (no insulation) may continuously attain higher temperatures than motors with insulated windings. However, in larger motors, the concentration of the rotor losses during starting is higher than in other parts. The starting time of such motors is therefore limited by the thermal capacity of the rotor. These types of motors are commonly referred to as "rotor-critical" motors. Critical to the rotor are the mechanical stresses caused by the temperature rise, unsoldering of the rotor bars, and, for EExe motors (motors for use in the chemical industry), the high temperature as a source of ignition.

1.4 Operational Requirements for the Installation

Monitoring application parameters and process data of an installation can be very important. Even slight change in the starting and operating behavior of the motor can indicate impending fault. The CET 4 helps eliminate the potential trouble before major repairs are necessary and loss of production occurs.

The CET 4 fulfils these requirements by providing the following protective functions:

- high overload, stalling and jam
- underloading
- wrong direction of rotation

1.5 Personnel and Installation Safety

Personnel protection in the the vicinity of control equipment is of primary importance. The corresponding requirements of regulatory agencies are therefore becoming increasingly severe. The CET 4 reflects this by providing the following protection:

- Equipment construction
  - -Touch protection
  - -Insulated housing
- Motor protective functions:
  - -Earth (ground) fault
  - -High overload, stalling and jam
  - -Wrong direction of rotation

1.6 CET 4 as an Automation Component

The CET 4 electronic control and protection system detects abnormal operating condition and faults in a motor branch circuit. The data made available by the CET 4 can be used for operational control and optimization of the installation.

A large number of supervisory, protective, and control functions improve operational control and avoid unnecessary down-time. This maximizes your motor investment, making the CET 4 a valuable component of modern automation systems.

Chapter 2 Description of the Equipment

2.1 Overview

This chapter contains the following sections:

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2.2 System Structure

The CET 4 is a microprocessor-based modern protection and control system for motors. For the AC motor and the operated installation this means:

- Maximum utilization
- Continuous supervision
- Reliable protection

The modular structure of the system as well as all of its possible functions enable the CET 4 to be adapted economically and optimally to any installation.

2.2.1 System Components

The motor protection system is comprised of:

- The control and protection unit, CET 4
- Current converter module CWE 4 for 0.5 ... 630 A
- A connecting cable between CET 4 and CWE 4
- Optional plug-in printed circuit boards
- A thermal utilization meter, CUD 4, to indicate the thermal load

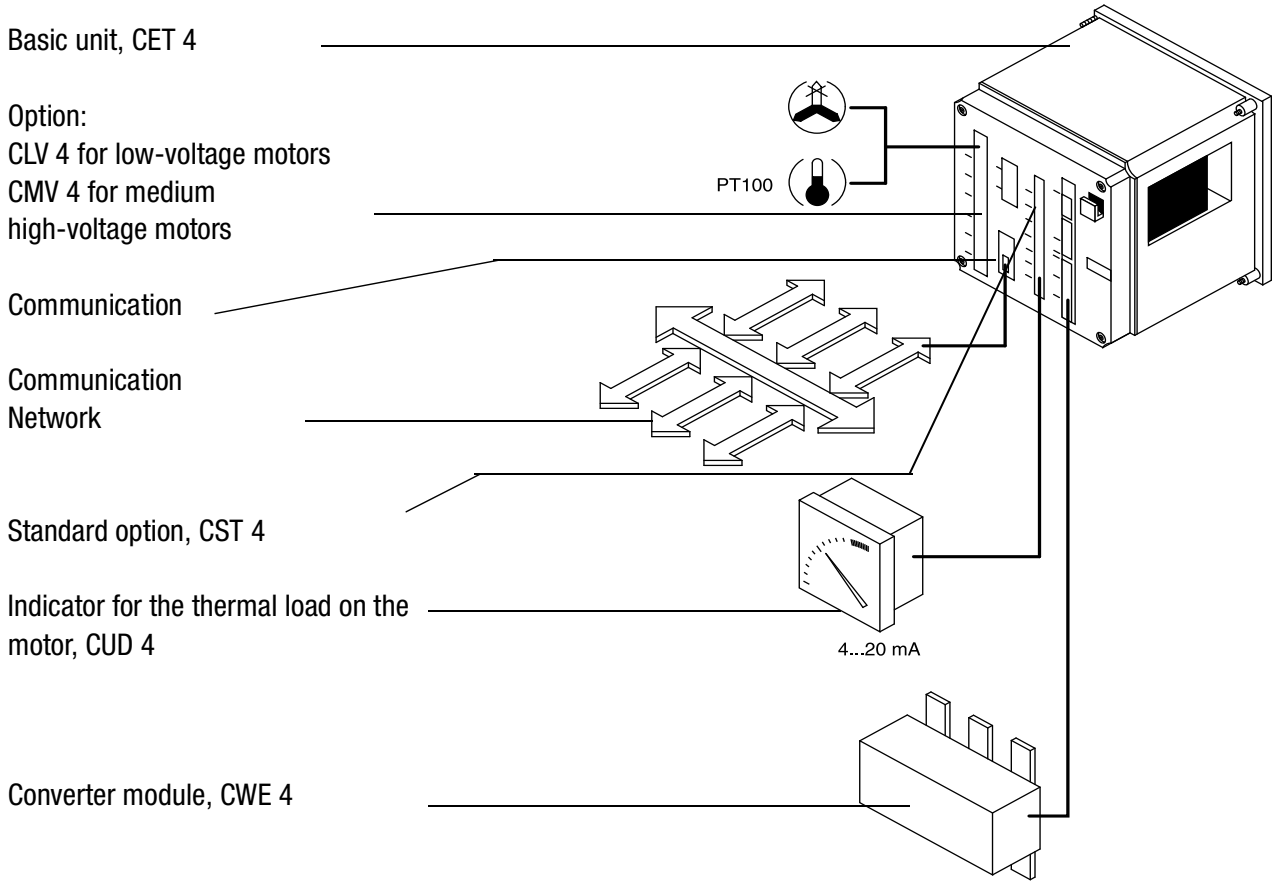
2.2.2 Installation

The CET 4 can be either flush mounted in an enclosure door, or surface mounted to the enclosure mounting plate using a panel mounting frame.
Current converter modules, CWE 4, can be surface mounted.

2.2.3 Modular Design

The CET 4 basic unit can be fitted with additional option (function) cards to suit the requirements.

Figure 2.1 Modular Design of the CET 4 Control and Protection System

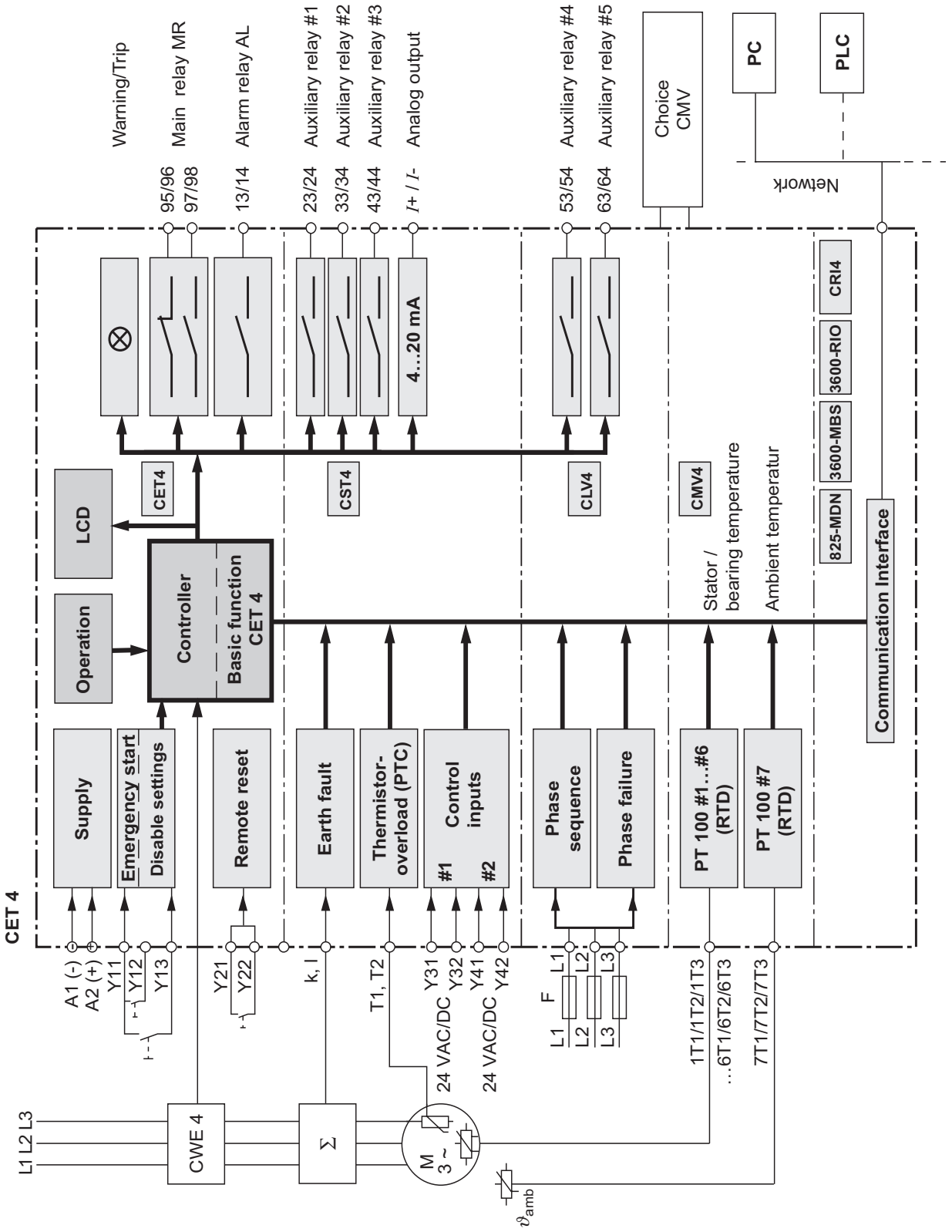


Available Communications Cards

825-MDN:	DeviceNet
3600-RIO:	Remote I / O
3600-MBS:	ModBus
CPB 4:	PROFIBUS

2.2.4 Block Diagram

Figure 2.2 Block Diagram



2.3 Operating Elements

The CET 4 electronic motor protection system is very easy to operate. With six membrane keys and the LCD, all functions, data, and tests can be entered, executed, or displayed. On the single-line LCD, all available data and functions are displayed.

Figure 2.3 Front View with Operating Elements

❶ Fault indicator (LED)
-Flashing: warning
-Steady state: trip

❷ LCD: Single line
-Two lines of text are displayed alternately

❸ Values: Selection of mode
-Actual: indication of actual operational data
-Set: setting mode (set/modify, store parameters)
-Recorded: indication of statistical data

❹ Select: Select function and enter/change operating parameter

❺ Settings: Enable entry (Change) and memorize (Enter)

❻ Test: Verifies operation of .

❼ Reset: Enables the after a trip.

2.4 Technical Data Basic Unit and Converter Module

2.4.1 Ambient Condition

Temperature	
Operation	-5 to + 60 °C (23 to 140 °F)
Storage	-40 to + 60 °C(-40 to 140 °F)
Transport	-40 to + 85 °C (-40 to 185 °F)
Climatic Withstand	
Damp heat IEC 68-2-3	40 °C (104 °F), 92 % relative humidity, 56 days
Climatic cycling IEC 68-2-30	25/40 °C (77/104 °F), 21 cycles
Enclosure Protection Class	
CET 4, enclosed in panel	IP65
Terminals	IP20
Resistance to Vibration	
as per IEC 68-2-6	10 ... 150 Hz, 3 G
Resistance to Shock	
as per IEC 68-2-27	30 G, shock duration 18 ms, half a sine wave in x, y, z directions

2.4.2 Nominal Rated Voltages U_e

Primary Detection Circuit	CWE 4-2.5	CWE 4-20	CWE 4-180 CWE 4-630 CWE 4-630N
Motor Circuit			
as per IEC, SEV, VDE 0660	400 VAC	660 VAC	1 000 VAC
as per CSA, UL	240 VAC	600 VAC	600 VAC
Control Circuit			
Main relay (MR) 95. . .98, supply A1, A2			
Phase sequence protection L1, L2, L3			
as per IEC 947	400 VAC		
as per SEV	380 VAC		
as per UL, CSA	240 VAC		
Alarm relay (AL) 13/14 Auxiliary relay #1, #4, #5			
as per IEC 947	400 VAC		
as per SEV	250 VAC		
as per UL, CSA	240 VAC		
Auxiliary relays #2, #3	50 VAC / 30 VDC		
Control inputs #1, #2	24 VAC/DC		

2.4.3 Electrical Tests

Test Voltage	CWE 4-2.5	CWE 4-20	CWE 4-180 / 630 / 630N
Motor Circuit			
as per IEC 947-1	U_{imp} 2.5 kV	U_{imp} 6 kV	U_{imp} 8 kV
Control Circuit			
Between control circuits and to all other circuits ❶ Main relay (MR) 95. . .98, supply A1, A2 Phase sequence protection L1, L2, L3 Alarm relay (AL), Auxiliary relay #1, #4, #5 as per IEC 947-4	U_{imp} 4 kV		
Core balance c.t. k, l Control inputs #1, #2 Auxiliary relays #2, #3 as per IEC 947-4	U_{imp} 2.5 kV		

❶ The measuring inputs for PT100 and PTC, the 4. . .20 mA output and the communication interface are not isolated from one another.

2.4.4 Standards

EMC

Noise emission as per EN 50 081-1 and as per EN 50 081-2
Noiseproof as per EN 50 082-1 and as per EN 50 082-2

Standards

IEC 947-4, CSA C22.2 No.14, UL 508

Approvals

CE, UL-Listed, CSA,
PTB: **P**hysikalisch-**T**echnische **B**undesanstalt (Germany). Testing institute. Certfication requiered for motor protection in explosion hazard areal (e.g. Chemikal-, Petrochemical-Installations).

2.4.5 Supply

Nominal supply voltage U_s	50/60 Hz, 22 ... 24, 33 ... 36, 44 ... 48 110 ... 120, 220 ... 240, 380 ... 415, 440 VAC 24 ... 48, 72 ... 120 VDC
Permissible voltage fluctuation	AC 0.85 ... 1.1 U_S DC 0.80 ... 1.1 U_S
Power consumption	AC 13 VA, DC 10 W max.
Short-circuit protection	With the appropriate supply cable rating, the supply module is short-circuit proof.

2.4.6 Relays

Contact Data of Output Relays					
Main relay (MR) 95 ... 96					
Contacts fitted		1 N/C and 1 N/O contact, galvanically separated			
Nominal operating voltage as per UL, CSA: pilot duty 240 V	[V]	24	110 ... 125	220 ... 250	380 ... 440
Continuous thermal current	[A]	4			
Rated operating current for AC-15	[A]	3		3	1.2
Rated operating current for DC-13 without prot. network, L/R = 300 ms	[A]	2	0.3	0.2	–
Max. permissible switching current (cos φ = 0.3) AC-15	[A]	30		30	12
Max. rated current of back-up fuse:	[A]	fast (D) 16 A; slow (DT) 10 A			

Alarm relay (AL), Auxiliary relays #1, #4, #5	
Contacts fitted	1 N/O contact each
Continuous thermal current	4 A
Max. permissible switching voltage	400 VAC, 125 VDC
Nominal operating current	
cos φ = 1	4 A at 250 VAC or 30 VDC
cos φ = 0.4, L/R = 7 ms	2 A at 250 VAC or 30 VDC
Max. switching power	
cos φ= 1	1 250 VA, 150 W
cos φ = 0.4, L/R = 7 ms	500 VA, 60 W
as per UL/CSA	240 V, 1 A pilot duty
Auxiliary relays #2, #3	
Contacts fitted	1 N/O contact each
Continuous thermal current	4 A
Max. permissible switching voltage	48 VAC, 30 VDC
Max. switching power	
cos φ = 1	150 W
cos φ = 0.4, L/R = 7 ms	60 W

2.4.7 Terminals

CET 4 plug-in terminals	Range of gauges: 0.5 ... 2.5 mm^2, single wire (AWG No. 20...14) 0.5... 1.5 mm^2, double wire (AWG No. 20...16)
as per UL	AWG No. 22 ... 14
as per VDE	nominal gauge 1.5 mm^2
Main circuit	
CWE 4-2.5 / CWE 4-20	Terminals: 2 x 2.5 mm^2/1 x 4 mm^2 (2 x .0039 in^2 / 1 x .006 in^2) 2 x AWG No. 20 ... 14 /1 x AWG No. 20 ... 12
CWE 4-180	Aperture or busbars: Wire ∅ 19 mm max. 20/16 x 4 mm
CWE 4-630(N)	Bus bars: 25 x 8 mm

2.4.8 Main Current Transformers (CTs) for the Motor Circuit

When the CET 4 is used as secondary relay with CWE 4-2.5 / CWE 4-20, note the specifications below.

Recommended current transformer in the phases		
Minimum nominal operating voltage	Nominal operating voltage of motor	
Minimum rated primary current I_{1n}	Nominal operating current of motor	
Rated secondary current	1 A or 5 A	
Class and nominal overcurrent factor	5 P 10 ext. 120 % ❶	
Power rating	According to power consumption in leads and measuring circuits	
Rated frequency	50/60 Hz	
Burden:	CET 4 + CWE 4-20	CET 4 + CWE 4-20
Power consumption at max. rated current ❷	0.1 VA/phase	0.4 VA/phase
Thermal limit continuous current	3 A	24 A
Thermal limit current 1 sec.	250 A	600A
Frequency of input current	50/60 Hz	50/60 Hz
General notes on CWE 4		
No-load	An open-circuit secondary is permitted, as the burden is installed in the detection module	

❶ Protection current transformer (P = protection)
± 1 % error at rated current; ± 5 % error rated overcurrent (10 I_e)
Rated thermal current = 120 % rated current
(if I_e motor > 87 % of rated current transformer current).
With starting current 10 I_e: class 5 P 20
The current transformer error adds up to the CET 4 error

❷ 2.5 A with CWE 4-2.5, 20 A with CWE 4-20

2.4.9 Core Balance Current Transformer

Recommended Data for Core Balance Current Transformer

Nominal ratio $K_n = \frac{\text{minimum detectable earth (ground) fault}}{\text{Pickup current of earth (ground) fault protection CET 4}}$

Burden: Measuring circuit CET 4	
Power consumption at max. rated current	0.4 VA
Thermal limit continuous current	0.5 A
Thermal limit current 1 sec.	25 A
Frequency of input current	50/60 Hz

A core balance current transformer, CTO 4, current ratio = 100:1, is available, which might suit most applications. (Max. earth (ground) fault current = 30 A.

2.4.10 Short-circuit Protection

Choosing a circuit-breaker or fuse and associated contactor

The branch circuit short-circuit protective device series (circuit-breaker or fuse) must, on the one hand, assure that the motor can start and, on the other, interrupt short-circuit currents rapidly enough to prevent damage to the installation. For the latter reason the fuse rating should be as low as possible.

The lowest possible fuse rating depends on the starting current of the motor and the tripping time set on the CET 4.

The short-circuit coordination of the starter must allways be taken into account.

The contactor receives its tripping signal when the CET 4 trips and must interrupt all currents up to the point of intersection of the time / current characteristics of the CET 4 and the circuit-breaker or fuse.

When starting large motors, the main contacts on the contactor are subjected to high thermal loads so that if the motor starting time exceeds a certain limit, the maximum permissible current has to be reduced.

The rating of the fuse or contactor must also allow for the prospective short-circuit current. The CWE 4 converter modules are short-circuit proof.

The coordination (grading) diagrams for contactors are available on request.

2.4.11 Response Supply Voltage Failure

If the supply voltage fails, the setting data are retained.

Failure of Supply Voltage > 30 ms

- All energized output relays drop-out
- The LED extinguishes
- The timer for "duration of supply failure" starts (maximum 8 h)
- The instantaneous set and statistical data are recorded
- The LCD extinguishes

Recovery of the Supply Voltage

- Start of initialization routine
- The time of occurrence and the duration of the supply failure are memorized
- Calculate the thermal image and update
- All output relays return to the state before the supply failure
- LCD and LED are active

2.5 Automatic Recognition of Converter Module

2.5.1 The CET 4 regulary checks:

- The link between CET 4 and CWE 4
- Agreement between the rated current set on the CET 4 and the current range of CWE
- The supervisory circuits

In the event of a fault, the output relay MR trips and the type of fault is displayed on the LCD.

Verify	Sequence	Display
Link between CET 4 and CWE 4	• After switching on supply • Supervision while motor is stationary • When running, as soon as the link is interrupted the CET 4 will trip and display one or more of the following causes: - short circuit, thermal, earth fault (Holmgreen = Residual), asymmetry, over current	CWE 4 NOT CON
Agreement between CET 4 setting and current range CWE 4	• After switching on supply • After each change in setting of rated current	Ie OUT OF RANGE
Supervisory circuits	• Continuous monitoring (hardware errors, supply, etc.)	ERROR CWE 4

3.1 Overview

This chapter contains the following sections:

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3.2 Menu Overview, Operation

3.2.1 Menu Overview

3.2.1.1 ACTUAL VALUES

Display List		Option	Page
I MOTOR	A		6-6 ... 6-7
TH UTILIZ	%		
I 1	%Ie		
I 2	%Ie		
I 3	%Ie		
TRIP IN	sec		
RESET IN	sec		
ASYM	%		
I earth - H	%I		
I earth - C	mA		
Tambient	°C	CMV 4	
PT100 #1(…6)	°C	CMV 4	
PROBUS		CPB 4	
RIO		3600-RIO	
MODBUS		3600-MBS	
DevNet		825-MDN	

3.2.1.2 SET VALUES

Parameter List	Option	Page
THERMAL PROTECTION		5-2 ... 5-18
THERMAL PROTECTION WARNING		
ASYMMETRY PROTECTION TRIP		
ASYMMETRY PROTECTION WARNING		
OVERCURRENT PROTECTION TRIP		
OVERCURRENT PROTECTION WARNING		
EARTH FAULT PROTECTION		
EARTH FAULT HOLMGREEN TRIP		
EARTH FAUILT CORE TRIP	CST 4	
EARTH FAULT CORE WARNING	CST 4	
SHORT CIRCUIT PROTECTION	CST 4	
UNDERLOAD PROTECTION TRIP		
UNDERLOAD PROTECTION WARNING		
STAR DELTA STARTING	CLV 4	
WARM STARTING		
START INHIBIT		
START CONTROL		
MAIN RELAY CONNECTION		
ALARM RELAY CONNECTION		
THERMAL RESET		
THERMAL RESET LEVEL		
COOLING CONSTANT RATIO		
PTC PROTECTION TRIP	CST 4	
PTC RESET	CST 4	
CONTROL INPUT #1 (DELAY AUX RELAY 2,	CST 4	
SPEED SWITCH		
DISABLE FUNCTION		
CONTROL INPUT #2 (DELAY AUX RELAY 3,	CST 4	
NEW FULL LOAD CURRENT,		
DISABLE FUNCTION		
PHASE REVERSAL PROTECTION TRIP	CLV 4	
PHASE LOSS PROTECTION TRIP	CLV 4	
PT100 PROTECTION	CST 4	
OUTPUT 4 … 20 mA	CMV 4	
STATION NUMBER		
BAUD RATE		
CLEAR RECORDED VALUES		
FACTORY SETTINGS		

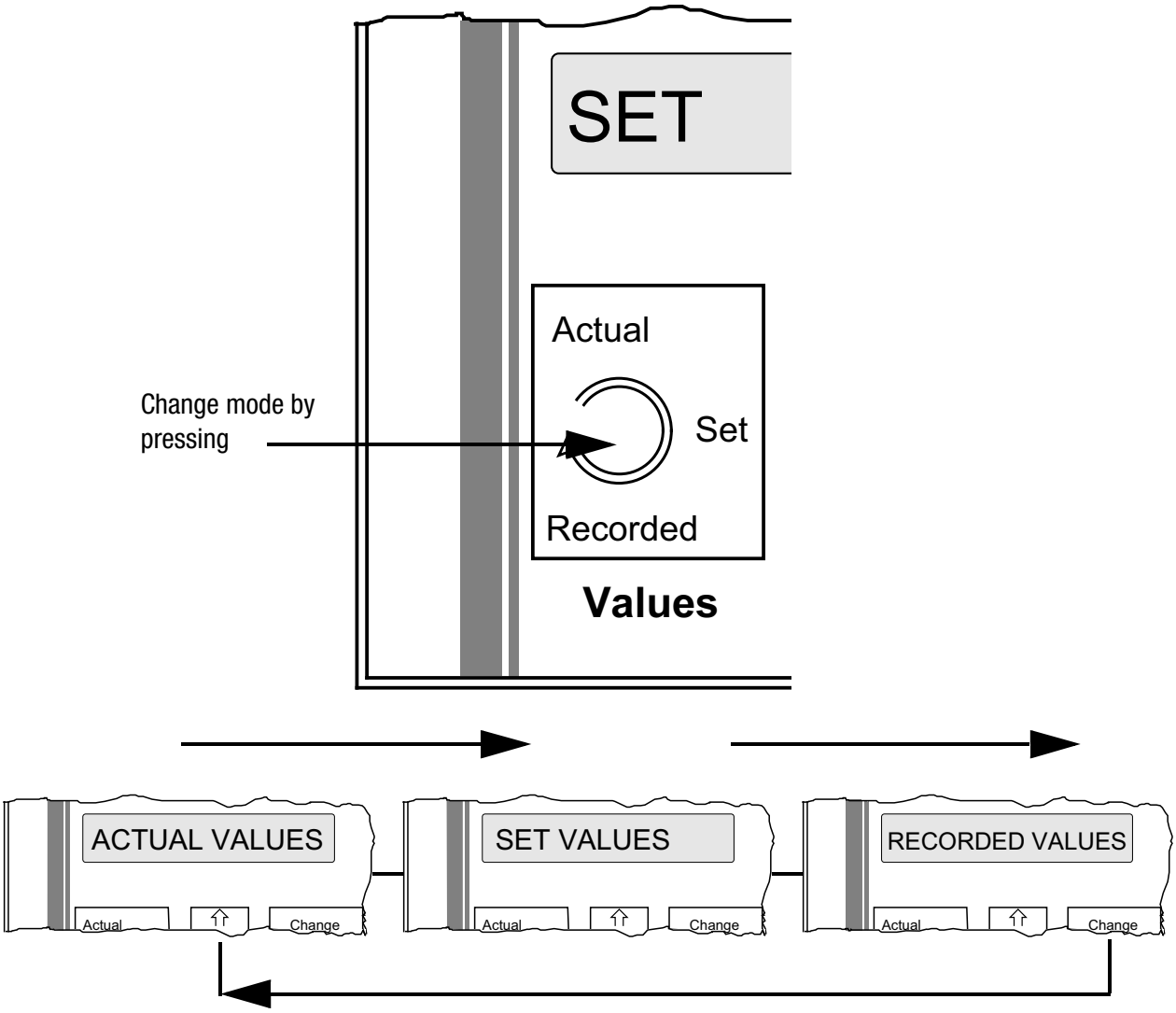
ATTENTION: All parameters can be set,including functions of option boards that are not mounted therefore. These warning- and trip functions are not operational!

3.2.1.3 RECORDED VALUES

Display List		Option	Page
CET 4 MAIN TIME	h min		7-2 ... 7-4
MOTOR RUNNING HR	h min		
SINCE LAST START	h min		
SINCE 1PRV START	h min		
SINCE 2PRV START	h min		
SINCE 3PRV START	h min		
SINCE 4PRV START	h min		
SINCE LAST TRIP	h min		
SINCE 1PRV TRIP	h min		
SINCE 2PRV TRIP	h min		
SINCE 3PRV TRIP	h min		
SINCE 4PRV TRIP	h min		
CAUSE LAST TRIP			
CAUSE 1PRV TRIP			
CAUSE 2PRV TRIP			
CAUSE 3PRV TRIP			
CAUSE 4PRV TRIP			
SINCE EMG START	h min		
SINCE POWER OFF	h min		
DURATION POW OFF	h min		
I BEF LAST TRIP	%Ie		
AS BEF LAST TRIP	%		
EF BEF LAST TRIP	mA, %I		
MAX T BEF L TRIP	°C	CMV 4	
TH BEF LAST TRIP	%		
NUMBER START			
NUMBER TH (AS, OC, EF, SC, UL, PTC, PR, PL, PT100) TRIP			

3.2.2 Operation

3.2.2.1 Selecting the Setting / Display Mode



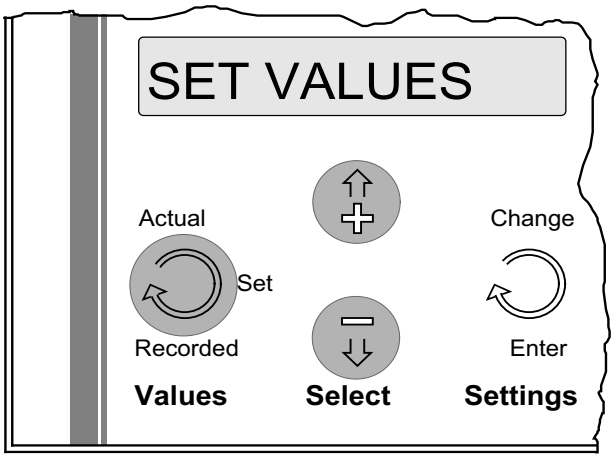
Indication of actual operational data	Setting mode (set/vary, store parameters)	Indication of statistical data

3.2.2.2 Setting the Operation Parameters (Set Values)

Text and data are indicated alternately (approximately 2 sec. text and 1sec. data). On the "second line," the data that is factory set or subsequently modified are displayed. Functions not activated (OFF) are not indicated.

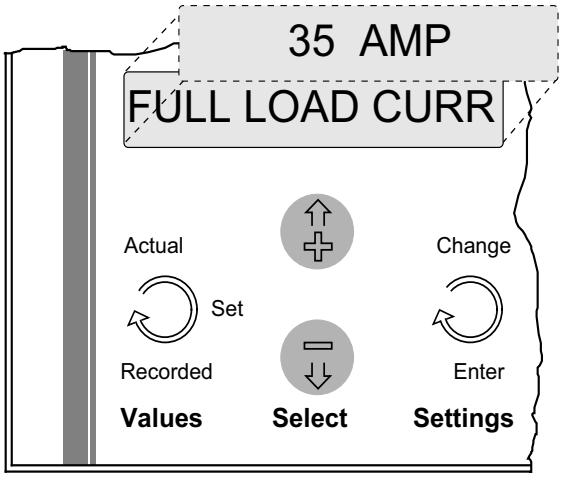
1. To set the operation parameters, repeatedly press the Values button until "SET VALUES" appears on the display.

Figure 3.1 Setting Mode



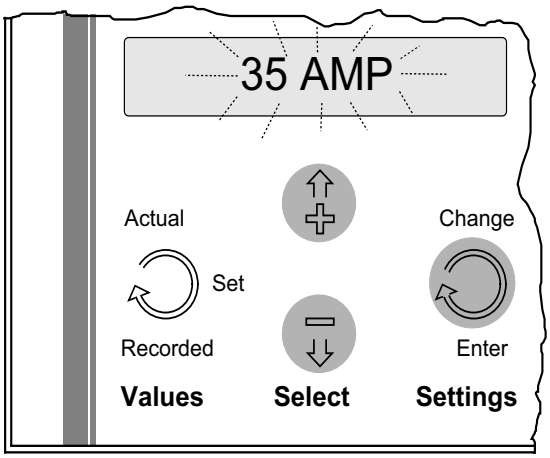
2. Press Select (Up or Down) until the desired parameter (e.g., "FULL LOAD CURR and 35 Amp) appears (display alternates between text and data).

Figure 3.2 Menu Selection



3. Press the Settings (Change) button once. The set value begins to flash. A new set value can now be entered by means of the Select keys (Up or Down). The entry is terminated by pressing Settings (Enter).

Figure 3.3 Entering a Data Value



Note: Hold down the select button to change the values more quickly.

Display Example

LCD	Range	Description
SET VALUES	–	Mode: setting parameters
FULL LOAD CURR 20 A	0.5 ... 2 000	Rated motor current in A
PRIMARY C.T. NO	No/Yes	Primary C.T. in use
PRIMARY C.T. RATIO 1	1 ... 2 000	Primary C.T. ratio
LOCKED ROT CURR 6 X Ie	2.5 ... 12	Locked rotor current as $\ldots I_e$
LOCKED ROT TIME 10 sec	1 ... 600	Maximum permitted time for the rotor to be stalled from cold
• • •	–	

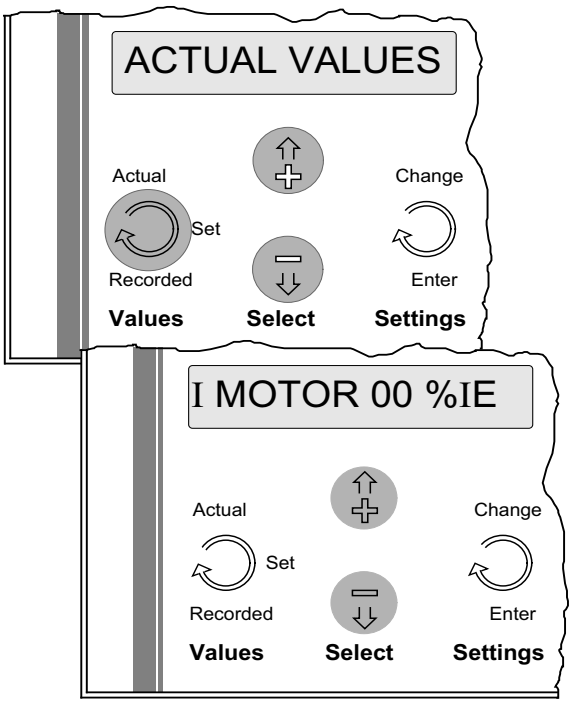
For a complete list of parameters, see Chapter 5.

3.2.2.3 Indications of Actual Values

In the mode "Actual Values," all operating parameters can be selected and read from the LCD.

1. Press Values until "ACTUAL VALUES" appears on the display.
2. Press Select (Up or Down) until the desired information is displayed.

Figure 3.4 Selecting the Actual Values



Display Example

LCD	Range	Description
ACTUAL VALUES	–	Display of the actual values
I MOTOR ... A	0.00 … 49.99 50 … 24 000	Motor current in A
TH UTILIZ...%	0...100	Thermal utilization
I MOTOR ... % Ie	0 / 20... 999	Motor current as percent of rated current
• • •	–	

For a complete list of parameters, see Chapter 6.

Applications

The Actual Values mode provides:

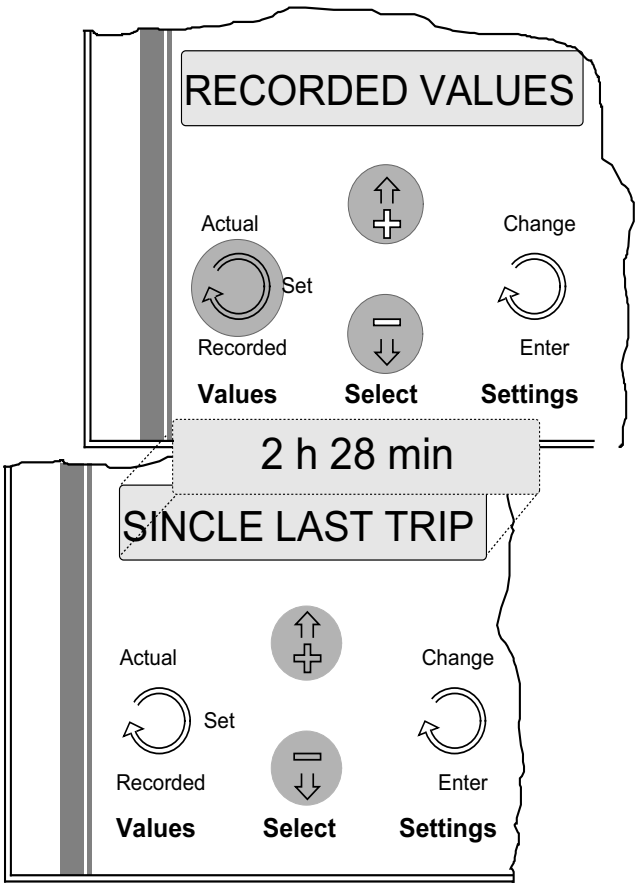
- Assistance during programming and set-up
- Verification after maintenance or production change
- Continuous operational supervision

3.2.2.4 Indications of Recorded Values (Statistics)

In the mode "Recorded Values," all recorded data can be selected and read from the LCD.

1. Press Values until "RECORDED VALUES" appears on the display.
2. Press Select (Up or Down) until the desired statistical information is displayed.

Figure 3.5 Selecting Recorded Data



Display Example

LCD	Description
RECORDET VALUES	Display of the statistical data
CET 4 MAIN TIME _ _ _ h_ _ _min	CET 4 running time (including interruption ≤ 8 hour of control voltage in hours, minutes)
MOT RUNNING TIME _ _ _h_ _ _min	Total motor running time in hours, minutes
• • •	

For a complete list of parameters, see Chapter 7.

Applications

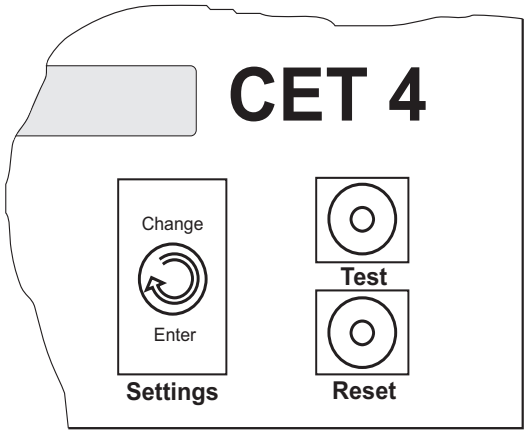
The Recorded Values mode provides:

- Analysis of motor faults and production interruptions
- Analysis of premature motor failures
- A means of determining maintenance jobs on switchgear, motor, and the installation

3.2.2.5 Test Button <Test>

When the motor is at standstill, the alarms, trips, and tripping times of the protective functions can be checked by pressing Test without external aids.

Figure 3.6 CET 4 Test Button



Testing the Thermal Trip

1. Press the Test button.

LCD:

```
TEST THERMAL ON
```

2. After the set blocking time has expired, the CET 4 musttrip.

LCD:

```
LOCK ROT TIME
_ _ _sec
```

3. The LED lights.

4. The selected output relay picks up (MR, Main Relay, on trip).

LCD:

```
THERMAL TRIP
```

Resetting

Automatic: The trip becomes inactive when the Test button is no longer pressed.

Manual: Reset the trip with the Reset button.

Note: After the test, the thermal image resumes its correct state. Simulation of the motor cooling is not affected by the test.

Testing the Trips (Asymmetry/Unbalance, Underload, etc.)

Example: Asymmetry

1. When in the Set Values mode, access the selected output relay:

LCD:

```
ASYMMETRY TRIP
AUX RELAY #2
```

2. If no output is assigned the following readout appears:
LCD: :

```
ASYMMETRY TRIP
NO OUTPUT RELAY
```

3. Press the Test button.
LCD: :

```
TEST
```

4. After the set trip delay expires, the CET 4 must trip.
LCD: :

```
AS TRIP TIME
_ _ _sec
```

5. The LED lights.
6. The selected output relay picks up.
LCD: :

```
ASYMMETRY TRIP
```

Resetting

Cancel the trip by pressing Reset.

Testing the Warning Functions

Example: Asymmetry warning

1. When in the Set Values mode, access the selected output relay:
LCD: :

```
AS WARNING
ALARM RELAY
```

2. Press the Test button.
LCD: :

```
TEST
```

3. The LED flashes and the selected output relay picks up immediately.
4. LCD flashes

LCD:

```
TEST
AS WARNING
```

Resetting

As soon as the Test button is no longer pressed.

3.3 Function Summary

3.3.1 Protective Functions

	Functions Factory Setting	Setting Range	Factory Setting	Tripping Delay Range	Factory Setting	Relays ❸ Selection	Factory Setting
CET 4 Basic Unit							
Thermal overload	On	–	–	–	–	MR	MR
Asymmetry (phase failure)	On	5 ... 80 %	35 %	0.5...25 sec.	2.5 sec.	All	MR
High overloading/Jam	On	1 ... 6 I_e	2.4 I_e	0.1 ... 5 sec.	0.5 sec.	All	MR
Underload	Off	25 ... 100 %	75 %	1 ... 60 sec.	10 sec.	All	MR
Underload delayed enable	On	–	–	0 ... 240 sec.	0 sec.	–	
Earth (ground) fault (Holmgreen)	On	10 ... 100 %	50%	0.1 ... 5 sec.	0.5 sec.	All	MR
Starting time monitor	Off	–	–	1 ... 240 sec.	10 sec.	All	MR
Limited starts per hour	Off	1 ... 10	2	–	–	All	MR
CST 4							
Short-circuit	Off	4 ... 12 I_e	10 I_e	20... 990 ms	50 ms	#1	#1
Earth (ground) fault (core balance c.t.)	Off	5 mA ... 50 A	1 A	0.1 .... 5 sec.	0.5 sec.	All	MR
Stalling during start ❶	Off	–	–	–	–	All ❶	MR ❶
Thermistor input (PTC)	Off	–	–	–	800 ms	All	MR
CLV 4							
Phase sequence (motor supply)	Off	–	–	–	1 sec.	All	MR
Phase failure (motor supply)	Off	–	–	–	2 sec.	All	MR
CMV 4							
PT100 input #1 ... #6 (RTD) (stator, bearings)	Off	50 ... 200 °C	50 °C	–	<8 sec.	MR, AL #1 ... 3	MR
PT100 input #7 (RTD) ❷	Off	–	–	–	–	–	–

❶ Via external speedometer (control input #1), output relay as for high overload.

❷ Allowing for the ambient temperature in the thermal image.

❸ Only one relay per function can be selected: MR = Main relay, AL = Alarm relay, Auxiliary relay #1 ... #5.

3.3.2 Warning Functions

ATTENTION: Warning function settings must be such that associated alarms are actuated before a trip occurs.

	Functions Factory Setting	Setting Range	Factory Setting	Tripping Delay Range	Factory Setting	Relays ❶ Selection	Factory Setting
CET 4 Basic Unit							
Thermal utilization (%$\Delta\vartheta$ load)	Off	50 ... 99 %	75 %	–	–	AL, #1 ... 5	AL
Asymmetry (% I_e)	Off	5 ... 80 %	20 %	–	–	AL, #1 ... 5	AL
High overloading (x I_e)	Off	1 ... 6 I_e	2 I_e	–	–	AL, #1 ... 5	AL
Underload	Off	25 ... 100 %	75 %	–	–	AL, #1 ... 5	AL
CST 4							
Earth (ground) fault (core balance c.t.)	Off	5 mA ... 50 A	500 mA	–	–	AL, #1 ... 5	AL
CMV 4							
PT100 input #1 ... #6 (RTD) (stator, bearings)	Off	50 ... 200 °C	50 °C	–	–	AL, #1 ... 5	AL

❶ Only one relay per function can be selected: MR = Main relay, AL = Alarm relay, Auxiliary relay #1 ... #5.

3.3.3 Control Functions

	Functions Factory Setting	Setting Range	Factory Setting	Tripping Delay Range	Factory Setting	Relays ❶ Selection	Factory Setting
CET 4 Basic Unit							
Warm start (% of "cold" trip)	Off	50...100 %	70 %	4...60 min	60 min	–	–
Emergency override of thermal trip	Off	Jumper term.	Y11-Y12	–	–	–	–
CST 4							
Analog output assigned to: - thermal utilization - PT100 max. temperature - I Motor	On	4 ... 20 mA 0 ... 100 % 50 ... 200 °C 0... 200 % I_e	–	–	–	–	–
CST 4, Control Input #1: (24 VAC/DC; 8 mA)							
One of three functions can be selected:							
1) Pickup delay, relay #2	Off	–	–	0...240 sec.	1 sec.	–	#2
1) Dropout delay, relay #2	–	–	–	0...240 sec.	2 sec.	–	#2
2) Speed switch	Off	–	–	–	–	–	high over-load relay

3) Disable protective functions:							
- Asymmetry/phase failure	Off	–	–	–	–	–	–
- High overload/jam	Off	–	–	–	–	–	–
- Earth (ground) fault	Off	–	–	–	–	–	–
- Short-circuit	Off	–	–	–	–	–	–
- Underload	Off	–	–	–	–	–	–
- Limiting starts/hour	Off	–	–	–	–	–	–
- PTC	Off	–	–	–	–	–	–
- PT100	Off	–	–	–	–	–	–
CST 4, Control Input #2: (24 VAC/DC; 8 mA)							
One of three functions can be selected:							
1) Pickup delay, relay #3	Off	–	–	0...240 sec.	1 sec.	–	#3
1) Dropout delay, relay #3	–	–	–	0...240 sec.	2 sec.	–	#3
2) Set second rated current ❷	Off	0.5 ... 2 000 A	20 A	–	–	–	–
3) Disable protective functions:							
- Asymmetry/phase failure	Off	–	–	–	–	–	–
- High overload/jam	Off	–	–	–	–	–	–
- Earth (ground) fault	Off	–	–	–	–	–	–
- Short-circuit	Off	–	–	–	–	–	–
- Underload	Off	–	–	–	–	–	–
- Limiting starts/hour	Off	–	–	–	–	–	–
- PTC	Off	–	–	–	–	–	–
- PT100 (RTD)	Off	–	–	–	–	–	–
CLV 4							
Star-delta starting	Off	–	Y-Δ at 1.1 I_e	Y-Δ at 1...240 sec.	10 sec.	–	Y: #4/Δ:#5

❶ Only one relay per function can be selected: MR = Main relay, AL = Alarm relay, Auxiliary relays #1 ... #5.

❷ For example, when used with two-speed motors

3.4 Functions of the Basic Unit CET 4

3.4.1 Thermal Overload

The CET 4 accurately simulates thermal conditions in the motor for all operating modes. This permits maximum utilization of an installation and assures safe protection of the motor.

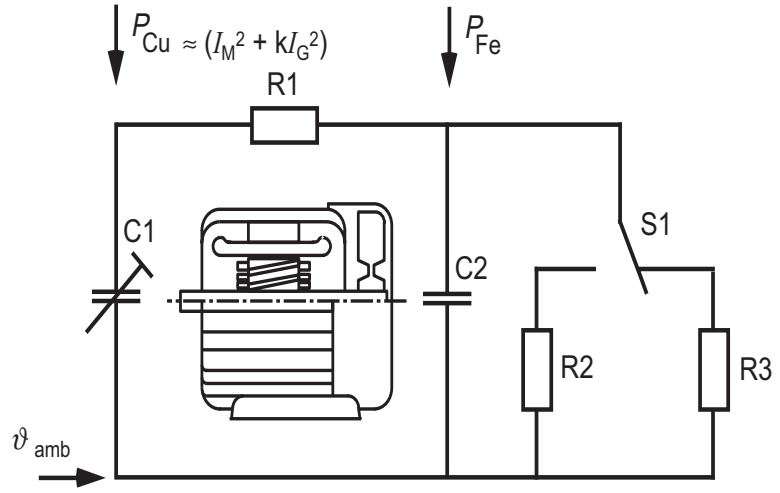
Specifically, a two-body simulation is utilized. The simulation accounts for the temperature rise of both the stator winding and the iron mass of the motor. For example, the rapid rise in temperature of the winding during a heavy start is simulated just as correctly as the subsequent transfer of heat to the iron, which heats up much slowlier.

The simulation of the Smart Motor Manager truly represents the conditions in the motor at all times.

While the motor is running, the iron losses as well as losses caused by asymmetry are fed to the simulation model. Allowance for the ambient temperature of the motor, as an option, enhances the maximum utilization of the installation even with considerable variation of the temperature. The different cooling conditions of a self-ventilated motor when running and at standstill are taken into account by two different time constants. After switching off, the rapid cooling of the winding to the iron temperature and the subsequent slow cooling of the motor as a whole are simulated.

The two-body simulation can be represented as a capacitance- resistance network, as shown in Figure 3.7.

Figure 3.7 Two-body Simulation of the Heating Up of a Motor



C1	Capacitance representing the heat capacity of the winding (adjustable)
C2	Capacitance representing the heat capacity of the iron an other masses of the machine
R1	Resistance representing resistance to heat transfer between winding and iron
R2	Resistance representing heat dissipation to the surroundings when stationary
R3	Resistance representing heat dissipation to the surroundings when running
P_{Cu}	Input of a current proportional to the copper losses
P_{Fe}	Input of a current proportional to the iron losses
S1	Changeover from stationary to running
I_M	Motor current
I_G	Opposing component caused by asymmetry
ϑ_{amb}	Allowance for the temperature of the environment coolant (optional PT100 #7)
k	Constant factor according to IEC and NEMA

3.4.2 Adjustable Ratio of Cooling Constants

The ratio of the cooling constant when the motor is at standstill to the cooling constant when it is running, allows for the difference in cooling in these states. The cooling constant ratio is set to 2.5 in the factory. This value has been found to be correct for the majority of AC motors that are self-cooled.

For separately ventilated and special motors, and above all those which respond very quickly or very slowly, you may have to modify the cooling factor.

3.4.3 Indication of the Time to Tripping

LCD:

TRIP IN ... sec

This feature provides continuous indication of the time remaining before tripping when in an overload condition. This enables you to intervene before tripping occurs. (No seconds-display means: Time > 10 000 sec.).

3.4.4 Indication of the Time until the Thermal Trip can be Reset

LCD:

RESET IN ... sec

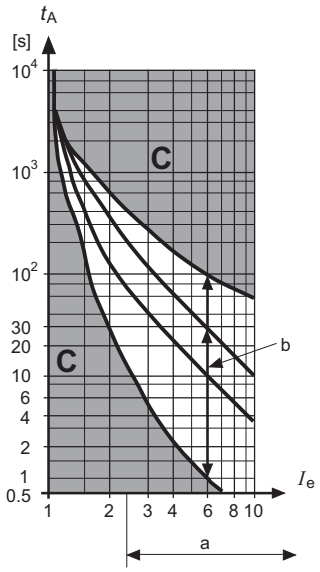
Following a thermal trip, the CET 4 may not be reset until the reset threshold has been reached. This is set to a temperature rise of 50 % in the factory.

3.4.5 Adjustable Setting Characteristic

The degree of inertia can be set to match the properties of the motor. A suitable reference value, among others, is the admissible locked-rotor time of the cold motor in conjunction with the associated current. This makes it possible to protect motors that are thermally very fast or very slow. Refer to Figure 3.8.

The thermal capacity of the iron is particularly important at small overloads. Allowing for this in the simulation enables the overload reserves of the motor to be utilized without risking a premature protective trip.

Figure 3.8 Time/Current Characteristic of the CET 4 Motor Protection System (from the cold state)



t_A Tripping time in sec.

I_e Rated service current of the motor = I_{eF}

a Locked-rotor current; setting range I_A = 2.5... 12 I_e

b Inertia: Setting range with appropriate set locked-rotor current t_{tA} = 1... 600 sec.

c out of range (blocked range)

Note: The setting of I_A/t_{tA} must be outside the range "c" (e.g., when I_A = 6 x I_e, t_{tA} must be ≤100 sec. and ≥1 sec.)

! For UL/CSA applications refer to page 9-10 !

Setting Parameters

Rated Current	Detection Module ❷				
	CWE 4-2.5	CWE 4-20	CWE 4-180	CWE 4-630	CWE 4-630N
Setting Range	0.5 ... 2.5 A (2 000 A) ❶	2.5 ... 20 A (2 000 A) ❶	20 ... 180 A	160 ... 630 A ❸	160 ... 630 A
Factory Setting	20 A	20 A	20 A	20 A	20 A
Setting Increments	0.01 ... 2 A	0.1 ... 2 A	1 A	2 A	2 A

❶ Up to 2 000 A, if primary CT's are used.

❷ -5 to 60 °C (23 to 140 °F)

❸ UL / CSA 160 ... 434 A

Locked-rotor Current (Multiple of Rated Current)	
Setting Range	2.5 ... 12 I_e
Factory Setting	6 I_e
Setting Increments	0.1 I_e
Locked-rotor Time (Admissible Locked-rotor Time of Cold Motor)	
Setting Range	1 ... 600 sec.
Factory Setting	10 sec.
Setting Increments	1 sec.
Cooling Factor of Motor On/Off ❶	
Setting Range	1 ... 5
Factory Setting	2.5
Setting Increments	0.5
Resetting the Thermal Trip	
Setting Range	10 ... 100 % of thermal utilization
Factory Setting	50 %
Setting Increments	1 %
Ultimate Release Current	
Incl. Setting Tolerance	1.05 ... 1.15 I_e

❶ The cooling factor can be modified to reflect different motor cooling with running motor and at standstill.

3.4.6 Protection Against Thermal Overload

	Warning	Trip
Response Level ❷		
Setting Range	55 ... 99 %	–
Factory Setting	75 %	100 %
Setting Increments	1 %	
Output Relay		
Selection	AL, #1 ... #5	–
Factory Setting	AL	MR
Function		
Factory Setting	Off	On

❷ Thermal utilization %

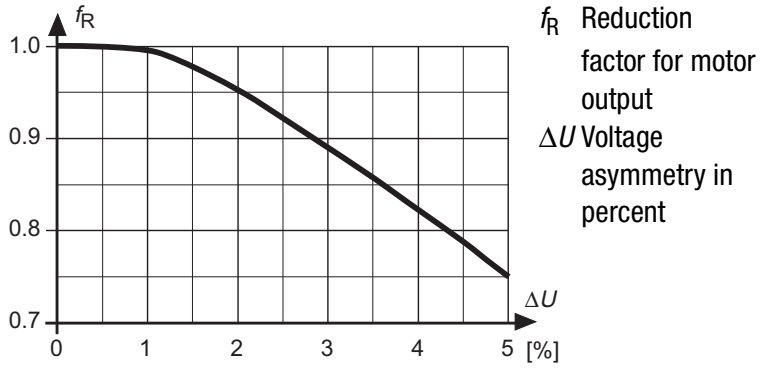
3.4.7 Asymmetry (Phase Unbalance) and Phase Failure

Asymmetrical phase voltages usually occur when the mains leads are too long. The resulting current asymmetry in the motor windings may then be 6 to 10 times the voltage asymmetry. The CET 4 takes into account the additional temperature rise and thus prevents the life of the motor from being reduced. Higher asymmetry, or the failure of a phase, can be caused by defective contacts in circuit breakers or contactors, loose terminals, blown fuses, and faults in the motor itself. Rapid detection and interruption of these help to prevent damage caused by overheating in such equipment. The stress on the installation and the motor bearings is reduced.

Definition of voltage asymmetry as per IEC and NEMA:

$$\Delta U(\%) = \frac{\text{(Max. deviation from the average of the phase voltages) x 100}}{\text{Average of the phase voltages}}$$

Figure 3.9 Reduction in Permissible Motor Output Due to Voltage Asymmetry as per IEC and NEMA



The CET 4 measures the three phase currents and calculates the total copper losses from the formula:

$$P_{Cu} \approx (I^2_M + kI^2_G)$$

Setting Parameters

	Warning ❶ (Current Asymmetry)	Trip ❶
Response Level		
Setting Range	5 ... 80 %	5 ... 80 %
Factory Setting	20 %	35 %
Setting Increments	5 %	5 %
Tripping Delay		
Setting Range	–	1 ... 25 sec. ±0.2 sec.
Factory Setting	–	2.5 sec. ±0.2 sec.
Setting Increments	–	0.5 sec.
Output Relay		
Selection (Relays)	AL, #1 ... #5	MR, AL, #1 ... #5
Factory Setting	AL	MR
Function		
Factory Setting	Off	On

❶ -5 to 60 °C (23 to 140 °F)

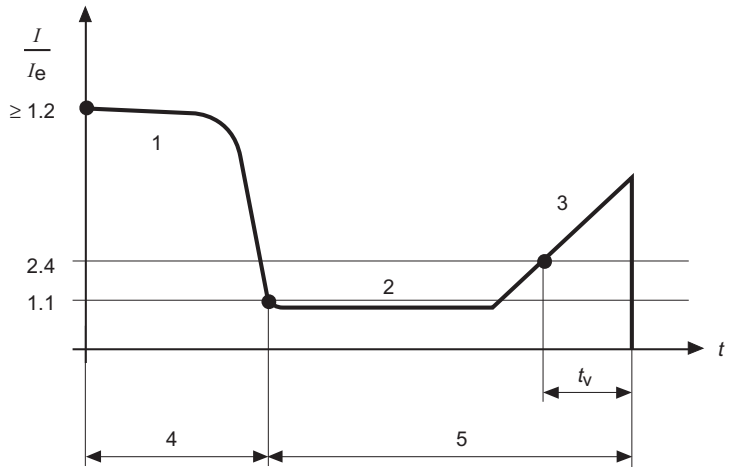
3.4.8 High Overload and Jam

When an overload is excessively high and the motor jams, unnecessary mechanical and thermal loading of the motor and transmission elements can be avoided by switching the motor off immediately. This reduces consequences of accident and loss of production. A gradually approaching overstress can be detected in good time and reported (e.g., bearing damage). The protective function activates as soon as the motor has started.

Application

- Conveying systems
- Mills
- Mixers
- Crushers
- Saws, etc.

Figure 3.10 Function of the Protection High Overload and Jam



1	Motorstart I ≥1.2 I_e	t_V	Tripping delay
2	Nominal operation	4	Jam protection not active
3	High overload or jam (tripping threshold)	5	Jam protection active

Setting Parameters

	Warning ❶	Trip ❶
Response Level		
Setting Range	1 ... 6 I_e	1 ... 6 I_e
Factory Setting	2 I_e	2.4 I_e
Setting Increments	0.2 I_e	0.2 I_e
Tripping Delay		
Setting Range	–	1 ... 5 sec. ±0.04 sec.
Factory Setting	–	0.5 sec. ±0.04 sec.
Setting Increments	–	0.1 sec.
Output Relay		
Selection (Relays)	AL, #1 ... #5	MR, AL, #1 ... #5
Factory Setting	AL	MR
Function		
Factory Setting	Off	On

❶-5 to 60 °C (23 to 140 °F)

ATTENTION: It is essential to set the response level "Warning" below the response level "Trip."

3.4.9 Underload

Motors that are cooled by the medium handled (e.g., fans, submersible pumps) can become overheated despite being underloaded. This can be a result of the absence of the medium or insufficient medium (due to clogged filters, closed valves, etc.). Often these motors are installed in inaccessible places, so repair is lengthy and expensive.

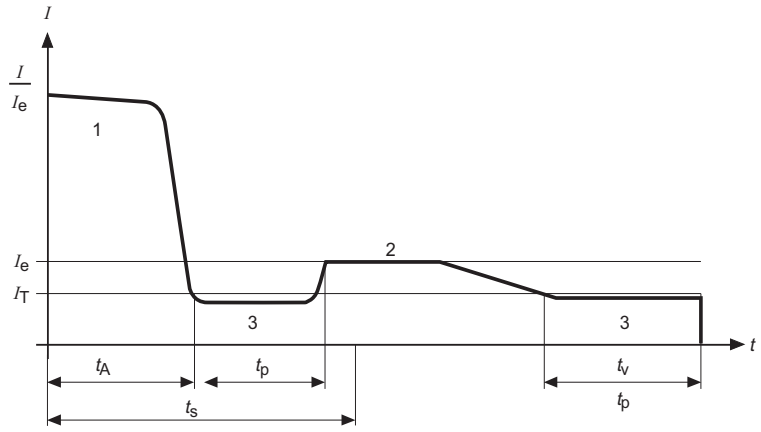
The consumption of less than a definite amount of current may indicate a mechanical defect in the installation (torn conveyor belt, damaged fan blades, broken shafts or worn tools). Such conditions do not harm the motor, but they do lead to loss of production. Rapid fault detection helps to minimize damage.

The underload protection trip time can be delayed following each start, so as to prevent tripping, provided e.g. a valve has to be kept closed. The warning is actuated as soon as the underload threshold is reached.

Application

- Submersible pumps
- Fans
- Conveyor systems
- Detection of features in mechanical transmission system

Figure 3.11 Function of the Underload Protection



1	Start	I_r	Tripping treshold
2	Nominal operation	t_s	Delayed activation (underload protection not active)
3	Underload operation		
t_A	Starting time	t_v	Tripping delay
I_e	Rated current	t_p	Warning

Setting Parameters

	Warning ❶	Trip ❶
Response Level		
Setting Range	❷	25 ... 100 % I_e
Factory Setting	❷	75 %
Setting Increments	❷	5 %
Tripping Delay		
Setting Range	–	1 ... 60 sec. -0.2 sec./ +0.4 sec.
Factory Setting	–	10 sec.
Setting Increments	–	1 sec.
Delayed Activation of Underload Protection		
Setting Range	–	1 ... 240 sec. +0.4 sec./ +0.8 s
Factory Setting	–	0 sec.
Setting Increments	–	1 sec.
Output Relay		
Selection (Relays)	AL, #1 ... #5	MR, AL, #1 ... #5
Factory Setting	AL	MR
Function		
Factory Setting	Off	On

❶ -5 to 60 °C (23 to 140 °F)

❷ For warning, the set Response Level is that for tripping.

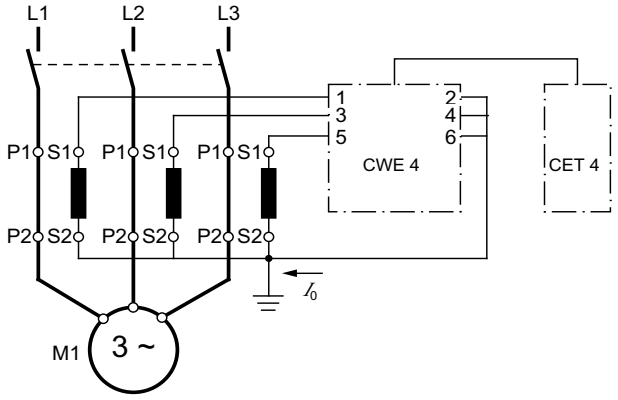
3.4.10 Earth (Ground) Fault

The insulation in motors is often damaged by high-voltage surges, which may be caused by lightning strikes, switching operations in the network, capacitor discharges and power electronics equipment. Other causes are aging and sustained or cyclic overloading, as well as mechanical vibration and the entry of foreign objects. Most insulation faults result in leakage to the grounded parts of the machine. In earthed networks, the fault current can rapidly rise to a very high value. Depending on the type of network and its requirements, monitoring of earth (ground) faults is performed either by the Holmgreen- = Residual- method or by using a core balance transformer.

3.4.10.1 Earth (Ground) Fault Protection by the Holmgreen Method = Residual Method (Solidly Earthed Networks)

To detect an earth (ground) fault current in either a solidly earthed network or one that is earthed through a low impedance, the currents in the three pole conductors are measured. In a "healthy" motor, this sum is zero. If a current is flowing to the frame of the motor, and thus to earth, a neutral current I_0, proportional to the fault current, is produced at the neutral of the c.t. This neutral current is detected by the earth (ground) fault detector and causes a trip. A brief delay helps to avoid nuisance trips caused by transient c.t. saturation, which can be caused by switching operations. The sensitivity has to be such that neither transformation errors in the c.t. nor disturbance signals in star-delta (wye-delta) connections caused by the third harmonic cause nuisance tripping.

Figure 3.12 Three-phase Current Detection
Measurement of the neutral current I_0 in the neutral connection of the c.t. to detect an earth (ground) fault (Holmgreen = Residual circuit)



Setting Parameters

	Trip ❶
Response Level	
Setting Range	10 ... 100 %
Factory Setting	50 %
Setting Increments	10 %
Tripping Delay	
Setting Range	0.1 ... 5 sec. ±0.2 sec.
Factory Setting	0.5 sec. ±0.2 sec.
Setting Increments	0.1 sec.
Output Relay	
Selection (Relays)	MR, AL, #1 ... #5
Factory Setting	MR
Function	
Factory Setting	On

❶ -5 to 60 °C (23 to 140 °F)

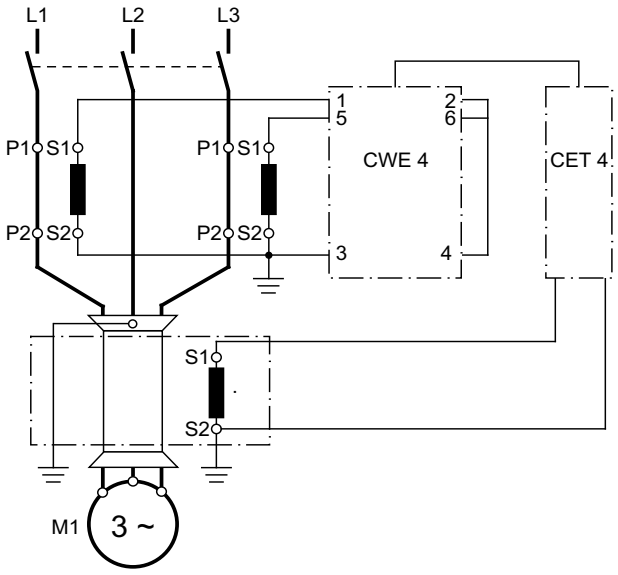
3.4.10.2 Earth (Ground) Fault Protection with a Core Balance c.t.

This function can be provided by the CST 4 option card.

In isolated, high impedance-earthed or compensated networks, the necessary high sensitivity is obtained by using a core balance c.t., whose core surrounds all three of the phase leads to the motor.

According to the principle of the residual current protection circuit breaker, sensitive protection against earth (ground) faults is possible. With a low response threshold quite a minor insulation fault can lead to a warning or trip at an early stage.

Figure 3.13
Example of two-phase current detection and core balance c.t. for sensitive earth (ground) fault protection (three-phase current detection is also possible)



Application

- High-voltage motors
- Installations in a difficult environment, with moisture, dust, etc. (e.g., mines, gravel pits, cement factory, mills, woodworking shops, water pumping stations, waste water treatment)

Setting Parameters

Core Balance c.t.	
Current ratio	
Setting Range	1 ... 2 000
Factory Setting	100
Setting steps	1

Setting Parameters

	Warning ❶	Trip ❶
Response Level		
Setting Range	5 mA ... 50 A	5 mA ... 50 A
Factory Setting	5 mA	5 mA
Setting Increments	5 mA	5 mA
Tripping Delay		
Setting Range	–	1 ... 5 sec. ±0.02 sec.
Factory Setting	–	0.5 sec. ±0.02 sec.
Setting Increments	–	0.1 sec.
Output Relay		
Selection (Relays)	AL, #1 ... #5	MR, AL, #1 ... #5
Factory Setting	AL	MR
Function		
Factory Setting	Off	On

❶ -5 to 60 °C (23 °F to 140 °F)

3.4.10.3 Earth (Ground) Fault Protection in High-voltage Systems

This subsection provides an overview of earth (ground) faults in isolated, high-impedance earth or compensated networks.

With networks of the mentioned earth neutral point types, the magnitude of the earth (ground) fault (leak) current is determined by the earth capacitance of the network and the earth resistance or the compensating reactor. Because the size of industrial networks is limited, earth fault currents are very small. To a great extent, earth capacitances are determined by the cables and the motors.

The capacitance values for cables are given in cable tables and are of the order of 0.2 ... 1.2 µF per km. A value between 0.02 ... 0.05 µF per MW of motor rating can be assumed for high-voltage motors.

A rule of thumb for industrial medium voltage networks is to allow about 1 A of capacitive earth current for every 1 000 ... 1 500 kVA of system power. Usually, a single neutral point is monitored for the entire network by measuring the displacement voltage.

The earth (ground) fault is localized by using an earth (ground) fault current detector such as the CET 4 Motor Protection System with earth (ground) fault protection in the motor feeders. Often, operation can continue since the earth currents are comparatively insignificant and the insulation of the non-faulty phases can be operated at a higher voltage for a short period of time.

3.4.10.4 Isolated or High-impedance Earth Networks

In the case of earth capacitances, the neutral point of the network assumes earth potential and the sum of the currents flowing through the earth capacitances is zero. Also, no current flows in normal operation in the high-value earth resistor (Figures 3.15, 3.17, and 3.19) in the case of transformer with neutral point. It avoids extreme overvoltages in the event of intermittent earth faults, such as can occur in isolated networks.

If, for example, phase conductor 3 (Figures 3.14 and 3.16) becomes connected to earth due to an earth fault, the two other phase conductors carry a line-to-line voltage with respect to earth. Through their earth capacitances, C_N (on the power supply side as seen from the CET 4) and C_M (on motor side), a capacitive current flows toward earth and back to phase conductor 3 through the fault location. In the case of high-impedance earthing (Figures 3.15, 3.17, and 3.19), the neutral point voltage, now at a high value, causes an additional current, that is limited by the earthing resistor through the fault location.

In the event of an earth fault on the power supply side of the measuring location (current transformer installation location), the CET 4 measures the component of the earth current flowing via C_M. The response sensitivity must be selected such that in this case, the CET 4 does not trip. On the other hand, earth fault detection by the CET 4 should be as sensitive as possible since in the case of earth faults in the motor windings, the displacement voltage becomes smaller the closer the fault location is to the neutral point. The fault current decreases proportionally. Normally, a response threshold is selected that is greater than 5 ... 10 % of the current that flows in the event of a dead earth fault at the motor terminals.

3.4.10.5 Neutralized Networks

Systems with earth fault neutralizers, resonant-earth system, Petersen coil. Although compensated industrial networks are rare, their main features are shown in Figures 3.15, 3.17, and 3.19. Under fully-compensated conditions, the compensation reactor supplies a current of the same magnitude as that of the capacitive fault current but phase shifted by 180° so that only a small ohmic residual current flows via the fault location.

3.4.10.6 Schematic Representation of Various Network Configurations and Earth (Ground) Fault Locations

The earth (ground) fault current measured by the CET 4 electronic motor protection unit with the aid of core balance current transformer is dependent on the power supply network configuration and on the location of the earth fault. The following diagrams indicate the relationships in the various applications.

The symbols used have the following meanings:

C_N	Earth capacitance of phase conductor on power supply system side
C_M	Earth capacitance of motor including supply conductors between current transformer and motor
L	Compensating Coil
R	High earthing resistance
T	Transformer
I_E	Earth (ground)fault current

Figure 3.14 Isolated Network: Earth Fault on the Network Side
The CET 4 measures the earth current component through C_M.

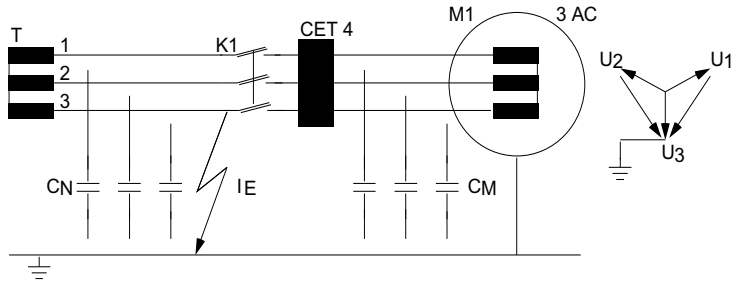


Figure 3.15 Network Earthed through a High Impedance: Earth Fault on the Network Side
The CET 4 measures the earth current component through C_M.
Compensated network: Through the fault a small current flows, given by the vectorsum of the earth currents.

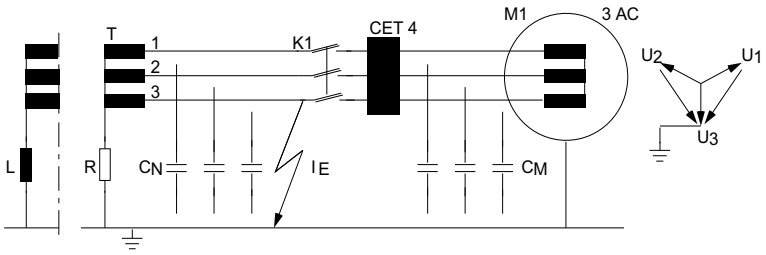


Figure 3.16 Isolated network: Earth (Ground) Fault on the Leads on the Motor Side
The CET 4 measures the earth current component through C_M.

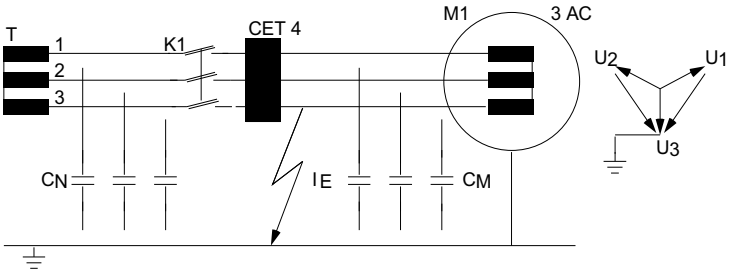


Figure 3.17 Network Earthed through a High Impedance: Earth (Ground) Fault on the Motor Leads

The CET 4 measures vector sum of the earth currents through C_N and the earthing resistance R.

Compensated network: The CET 4 measures vector sum of the earth currents through C_N and the compensating coil L.

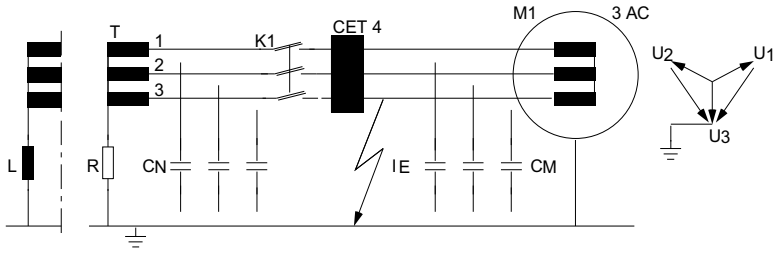


Figure 3.18 Isolated Network: Earth (Ground) Fault in the Motor

The nearer the fault is to the motor star-point, the smaller the fault current.

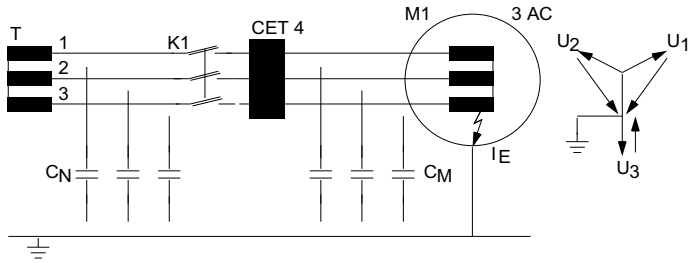
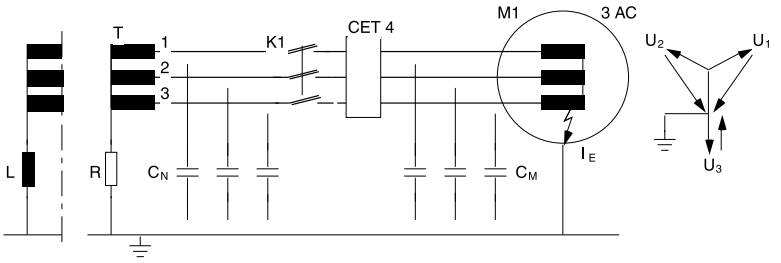


Figure 3.19 Network Earthed through a High Impedance: Earth (Ground) Fault on the Motor

The CET 4 measures vector sum of the earth currents through C_N and the earthing resistance R.

Compensated network: The CET 4 measures vector sum of the earth currents through C_N and the compensating coil L. The nearer the fault is to the motor star-point, the smaller the fault current.

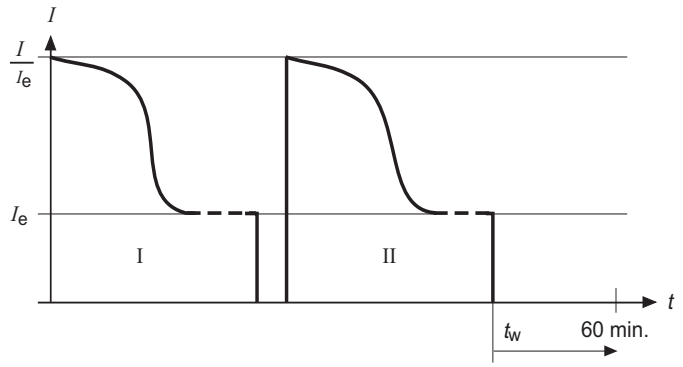


3.4.11 Limiting the Number of Starts per Hour (Start Lockout)

Function

When the set number of starts is reached and the motor is switched off, a new start is prevented. Depending on its setting, either the main relay changes to "Fault," or the selected auxiliary is activated.
As soon as a new start is permissible, the start lockout is automatically reset.

Figure 3.20 Function: Limiting the Number of Starts per Hour



I First start
II Second start
t_w The selected relay (MR, or #1... #5) remains in the tripped position until 60 min. have expired. If an additional start is allowed, the number of starts can be increased by one.

Setting Parameters

Setting	Limited Number of Starts
Setting Range	1 ... 10 starts/hour
Factory Setting	2 starts/hour
Setting Increments	1
Output Relay	
Selection (Relays)	MR, AL, #1 ... #5
Factory Setting	MR
Function	
Factory Setting	Off

ATTENTION: The motor manufacturer's instructions regarding the permissible number of starts per hour and the minimum waiting time between individual starts must be complied with.

Note: Independently of the limited number of starts per hour, the motor is protected thermally. Hence, another start depends on the thermal reserve of the motor.

3.4.12 Monitoring the Starting Time

Function

The starting time of the motor is monitored. If starting has not finished by the set time, the installation can be switched off.

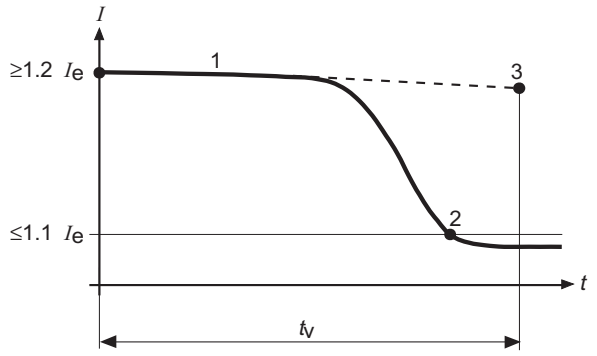
This monitoring is independent of the thermal state of the motor.

The beginning of a start is recognized by the CET 4, as such when the motor current reaches 1.2 I_e. Starting is deemed to have been completed when the motor current is less than 1.1 I_e.

Applications

- Installations in which an elevated load or stalling of the drive have to be detected during the starting stage, in order to avoid serious damage. Possible causes: overloaded installation, defective bearings, or transmission elements.

Figure 3.21 Monitoring Starting Time



1 Motor starting current ≥1.2 I_e
2 Rated conditions
t_V Max. starting time
3 Tripping if starting lasts too long

Setting Parameters

	Max. Starting Time ❶
Setting	
Setting Range	1 ... 240 sec. ±0.04 sec.
Factory Setting	10 sec. ±0.04 sec.
Setting Increments	1 sec.
Output Relay	
Selection (Relays)	MR, AL, #1 ... #5
Factory Setting	MR
Function	
Factory Setting	Off

❶ -5 to 60 °C (23 to 140 °F)

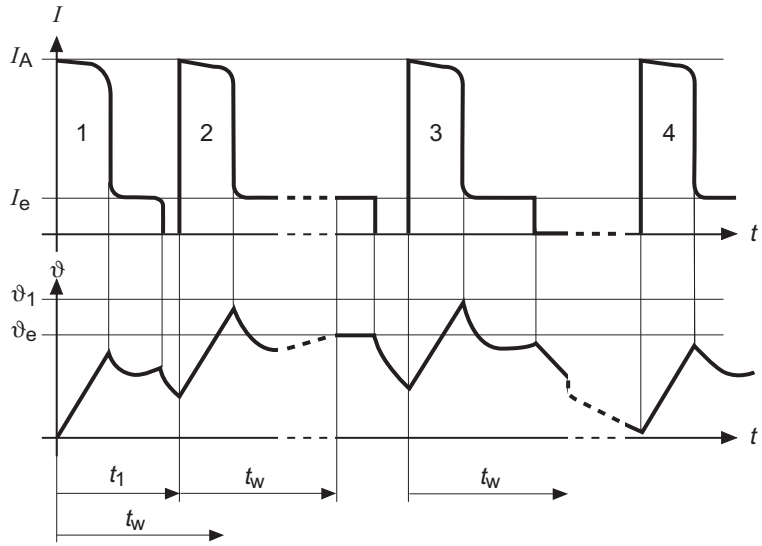
Note: With Star-Delta (Wye-Delta) starting, the total starting time (Star and Delta) is monitored. If immediate switch off is demanded in the event of stalling, monitoring must be provided by a zero speed switch (function "stalling during starting").

3.4.13 Warm Start

Function

The motor windings may be heated for a short time above the permissible temperature limit. This applies particularly to rotor-critical motors. The temperature that is permitted for this short period is approximately 250 °C and is thus appreciably higher than the continuous operating temperature of 100 ... 150 °C. This means that a motor warm from running has a relatively long permissible starting time. This property of the motor can be utilized with the CET 4. The CET 4 is factory-set for one warm start per hour. The tripping time is then 70 % of that from cold. The function warm start is switched off in the factory. As additional protection for the motor, too many warm starts can be prevented by the function "limiting the number of starts per hour."

Figure 3.22 Current and temperature curves for warm and cold starts of motor and the tripping limits of the CET 4



I_A Starting current
I_e Rated current
$ϑ_e$ Permissible temperature of the motor in continuous operation and normal tripping limit of CET 4 for continuous operation
ϑ1 Motor temperature permissible for a short time and tripping limit of CET 4 with modified characteristic for warm start

1 First start (cool)
2 First warm start
3 Second warm start
4 Cold start (after the motor has cooled down)
t_1 Minimum time before first start is possible ($t1>10t_{6Ie}$)
t_w Minimum waiting time warm starts (4 ... 60 min.)

ATTENTION: The motor manufacturer's instructions must be complied with, especially regarding the minimum wait between two starts

An attempt to start may be made before the time has elapsed. The CET 4 will trip during starting if the thermal capacity available is not sufficient.

Applications

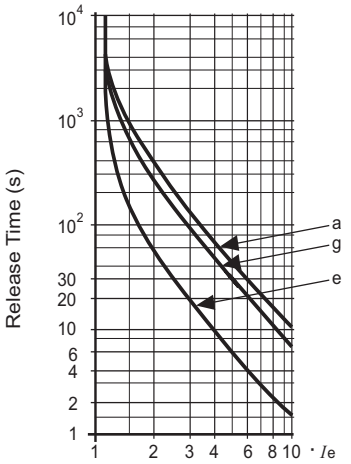
The Warm Start function can be used in any installation that may have to be re-started immediately after a voltage interruption.

- Chemical process and production plants (e.g., mixers, centrifuges, pumps, conveyor systems)

- Mines and tunnels (fresh air fans, water pumps)

Setting Parameters

Figure 3.23 Multiple of the Set Current I_e (= I_b)

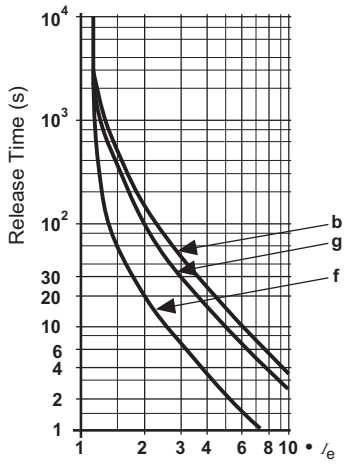


a Time/current characteristic fror cold when setting the tripping time t_{6xIe} = 30 sec.

b Time/current characteristic fror cold on the normal setting of the tripping time t_{6xIe} = 10 sec.

e Time/current characteristic afte preloading with Ie when trippin time t_{6xIe} is set to 30 sec.

Multiple of the Set Current I_e (= I_b)



f Time/current characteristic after preloading with Ie when tripping t_{6xIe} is set to 10 sec.

g Time/current for warm start when restarting after uninterrupted operation and 35 ... 100 % temperature rise Tripping time "warm“ = 70 % of tripping time "cold“.

	Tripping Time from Warm State as a Percent of Tripping Time from Cold State	Minimum Time Between Two Warm Starts
Setting Range	50 ... 100 %	4 ... 60 min
Factory Setting	70 %	60 min
Setting Steps	10 %	1 min
Function		
Factory Setting	Off	–

3.4.14 Emergency Override of Thermal Trip (Emergency Start)

Suggested Procedure

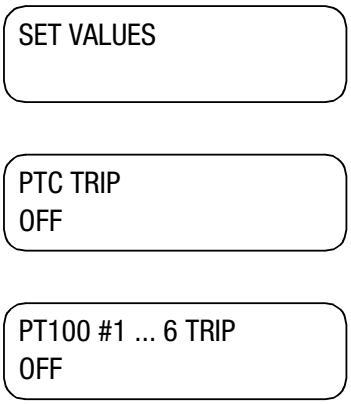
Procedure when PT100 and PTC are not used:

1. Momentarily bridge terminals Y11-Y12 (voltage free contact). A spring return key switch is recommended.
2. LCD flashes "EMERGENCY START."
3. If the thermal release has tripped, it can now be reset.
4. If the maximum number of starts per hour has been reached, the counter has one start deducted.
5. Start the motor.
6. As soon as the motor starts, the stator winding memory will be set to zero (copper losses only).

ATTENTION: Do not leave Y11-Y12 bridged, because each start will reset the copper memory

Additionel procedure when PT100 and/or PTC are installed:

1. Disable PTC and/or PT100.



2. Alternatively, the CET 4 can be set up such that inputs #1 and #2 de-activate the PTC and/or PT100 tripping. (This can be achieved with a separate switch or a separate set of contacts on the key switch) refer to page 3-49.
3. The input should remain activated until the temperatures return to normal.

3.4.15 LED Alarm and Trip Indicator

The LED indicator on the front of the CET 4 differentiates between two kinds of indication:

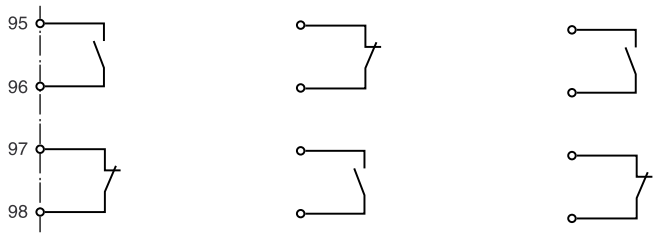
- LED flashing, indicates an alarm
- LED continuously lit, indicates a tripped condition

3.4.16 Connection of the Main Relay (MR)

The main Output Relay can be operated as fail-safe (electrically held) or non-fail-safe.

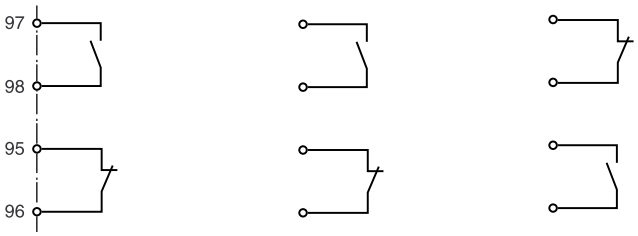
Fail-safe (Electrically Held) Mode

Supply Off *Supply On* *Supply On and Trip*



Non-Fail-Safe Mode

Supply Off *Supply On* *Supply On and Trip*



Applications of the Non-Fail-Safe Connection

The non-fail-safe connection is suitable for use in situations where the failure of the control voltage may not interrupt the process.

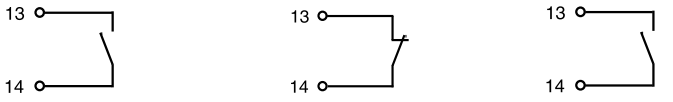
- Chemical processes
- Kneaders and mixers in which the mass would solidify
- Fresh air fans
- Cooling pumps, etc.

3.4.17 Connection of the Alarm Relay (AL)

In versions before 2.18 the Alarm Relay was connected in the non-fail-safe mode. Since V2.18 (and later) it can also be connected in the fail-safe (electrically held) mode.

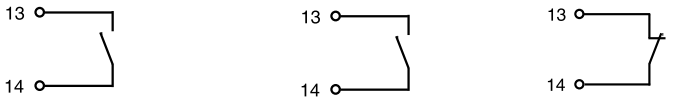
Fail-safe (Electrically Held) Mode

Supply Off | *Supply On* | *Supply On and Warning*



Non-Fail-Safe Mode

Supply Off | *Supply On* | *Supply On and Warning*



Applications of the Fail-safe (Electrically Held) Connection

Watchdog: monitoring the supply voltage when the Main Relay is in non-fail-safe connection.

3.4.18 Alarm Relay AL

Aside from the thermal overload, short-circuit, and thermistor PTC protective functions, all alarm and tripping functions may be assigned to the alarm relay (AL).

Examples

Warning	Factory Setting
Thermal Utilization	75 %
Asymmetry	20 %
High Overload	2 I_e
Underload	75 %
All these functions	Off

3.4.19 Reset

When the motor is at standstill, a trip condition can be reset.

Kinds of Reset

- Manual reset - Press the reset button on the CET 4 for at least 200 ms
- Remote reset - Short circuit terminals Y2l/Y22
- Automatic reset - In the mode "set values," set automatic reset for:
  - Thermal trip
  - PTC trip
  - PT100 trip

Reset Conditions

- Thermal - As soon as the temperature rise has dropped to the preset reset threshold.
- PTC detector - As soon as the temperature is below the reset threshold
- PT100 detector - As soon as the temperature is below the tripping threshold.
- Asymmetry/Phase failure - Manual or remote reset possible
- All other trips - Can be reset immediately.

Setting Parameters

Setting Range	Manual/Automatic
Factory Setting	Manual
Reset Threshold of the Thermal Trip	
Setting Range	10 ... 100 %
Factory Setting	70 %
Setting Increments	5 %

3.5 Function of the CST 4 Option Card

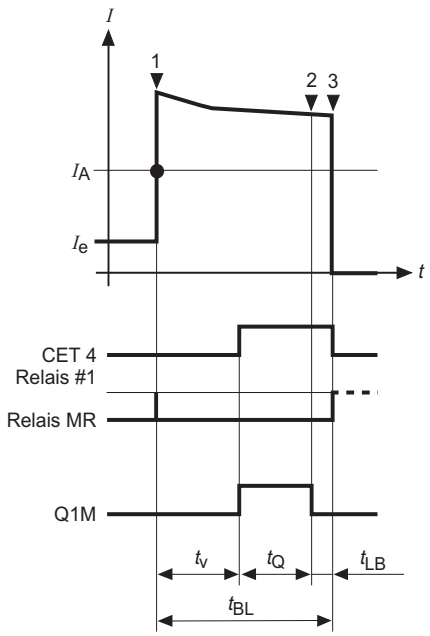
3.5.1 Short-circuit

Heavy phase currents caused by short circuits between phases and from phase to earth are detected by the CET 4 option card. The supply can be interrupted immediately by controlling the power switching device (e.g., circuit-breaker).

Short-circuit protection is always active. Therefore, the response level must be set somewhat higher than the maximum starting current.

Tripping is delayed by 50 ms. On the one hand, this enables the circuit breaker to be actuated rapidly, while on the other, unnecessary tripping by current peaks is prevented. In the event of a short-circuit, the separate output relay #1 (CST 4) trips, regardless of the other protective functions. The output relay #1 actuates a circuit breaker with adequate breaking capacity. To prevent the contactor from opening under short-circuit conditions, relay MR remains blocked at currents ≥ 12 I_e. If a thermal trip occurred shortly before the short circuit, relay MR assumes the tripped position as soon as the current has dropped to < 12 I_e.

Figure 3.24 CET 4 Diagram Showing Interruption of a Short-circuit



Q1M	Circuit-breaker (tripping relay)
I	Current curve
I_A	Pickup value
I_e	Rated service current
t_v	Tripping delay 50 ms
t_o	Operating time of the breaker
t_{LB}	Arc duration
1	Short-circuit
2	Contact separation
3	Short-circuit interruption
t_{BL}	Relay MR blocked at ≥12 I_e

Application

- Medium/high-voltage motors

ATTENTION: The function of short-circuit protection must not be used for switching off the contactor.

Setting Parameters

	Trip ❶
Response Level	
Setting Range	4 ... 12 I_e
Factory Setting	10 I_e
Setting Increments	0.5 I_e
Tripping Delay	
Setting Range	20 ... 990 ms
Factory Setting	50 ms
Setting Increments	10 ms
Output Relay	
Selection (Relays)	–
Factory Setting	#1
Function	
Factory Setting	Off

❶ -5 to 60 °C (23 to 140 °F)

3.5.2 Earth (Ground) Fault Protection with a Core Balance c.t.

This function is integrated into the CST 4. See description on page 3-26.

3.5.3 Stalling During Start

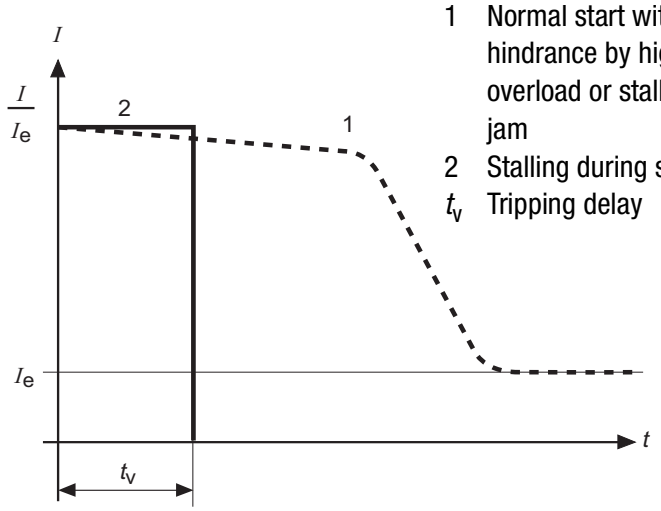
Function

If the motor stalls during the starting phase, the motor heats up very rapidly, and after the permissible stalling time, reaches the temperature limit of the insulation. Large, low-voltage motors, and especially medium/high voltage motors often have short, admissible stalling times, although their starts may be considerably longer. Accordingly, the permissible stalling time must be set higher on the CET 4. With an external speedometer or zero speed switch, the CET 4 recognizes that stalling has occurred during starting, and it switches the motor off immediately. Thus, the motor and the driven installation is not exposed to unnecessary or inadmissible stress from stalling.

Applications

- Large low-voltage motors
- Medium/high-voltage motors
- Conveyor systems
- Mills
- Mixers
- Crushers
- Saws
- Cranes
- Hoists, etc.

Figure 3.25 Stalling During Starting



1 Normal start without hindrance by high overload or stalling and jam
2 Stalling during standing
t_v Tripping delay

Setting Parameters

	Trip
Tripping Delay	
Factory Setting	Same time as set for the function "High overload/Jam" (see 3.4.8.) (settable only there).
Actuation	
Message from zero speed switch to control input #1	
Motor Running	24 VAC/DC at control input #1
Motor Standstill	0 VAC/DC at control input #1
Output Relay	
Selection (Relays)	Same relay as for function "High overload an Jam" (see 3.4.8.) (settable only there).
Function	
Factory Setting	Off

3.5.4 Thermistor Input PTC

Function

The thermistor detectors (PTCs) are embedded in the stator winding of the motor. They monitor the actual temperature of the winding. Influences independent of the motor current, such as ambient temperature, obstructed cooling, etc., are taken into account.

The detectors and their leads are monitored for short-circuit and open circuit.

Applications

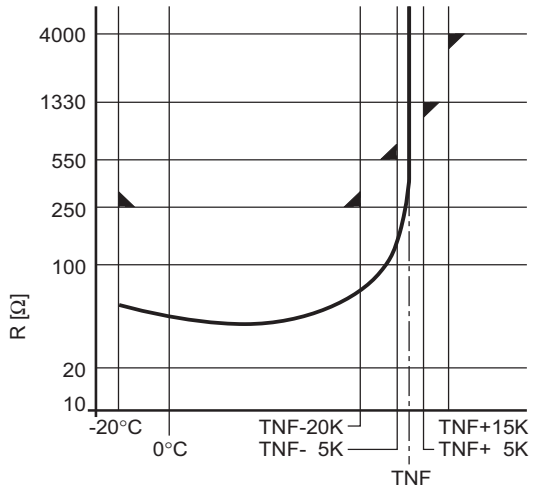
As additional protection for:

- Motors above 7.5 kW (10 HP)
- High ambient temperatures, dusty environment
- Varying loads
- Plugging, etc.

Setting Parameters

Sensor Measuring Circuit						
Max resistance of the PTC chain when cold		1.5 kΩ				
Max. number of sensors as per IEC 34-11-2		6				
Pickup value at δ_A = -5 .... +60 °C		3.3 kΩ ±0.3 kΩ				
Dropout value at δ_A = -5 ... +60 °C		1.8 kΩ ±0.3 kΩ				
Delay on pickup		800 ms ±200 ms				
Pickup value when short-circuit in Sensors circuit at δ_A = -5 ... +60 °C		≤15 Ω				
Measuring voltage as per IEC 34-11-2		< 2.5 VDC				
Measuring Lead						
Minimum Cross-section	[mm^2]	0.5	0.75	1.0	1.5	2.5
	[AWG No.]	20	18	17	16	14
Maximum Length	[m]	200	300	400	600	1 000
	[ft.]	656	984	1 312	1 968	3 280
Method of Installation ❶		up to 100 m (328 ft.) twisted, unscreened				
Output Relay						
Selection (relays)		MR, AL, #1 ... #5				
Factory Setting		MR				
Function						
Factory Setting		Off				

Figure 3.26 Characteristic of PTC Sensors as per IEC 34-11-2



TNF Nominal pickup temperature
R [Ω] Resistance to sensors

❶ Twisted lead: 25 times twisted per m
Screened lead: Screen connected to T2

3.5.5 Analog Output

This output supplies a current of 4 ... 20 mA proportional to one of the following selectable actual values:

- Thermal utilization (calculated temperature rise of the motor)
- Motor temperature (max. PT100 temperature)
- Motor current (% I_e)

Technical data

Output	4 ... 20 mA (IEC 381-1) at -5 ... +60 °C (23 to 140 °F)
Load	0 ... 300 Ω

3.5.5.1 Analog Output for Thermal Load or Motor Temperature (PT100 max.)

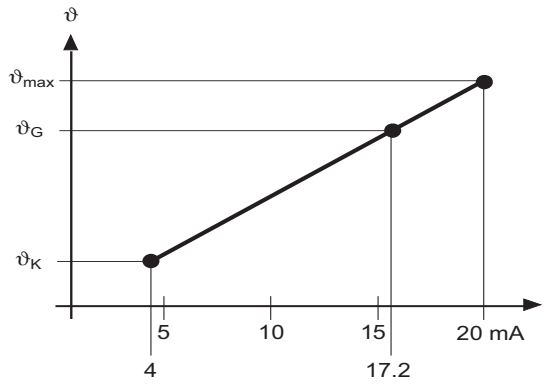
This output supplies a current of 4 ... 20 mA either proportional to the calculated temperature rise of the motor or the motor temperature (max. temperature of the operating PT100 Sensors). The thermal load in percentage is also indicated on the LCD of the CET 4.

Application

- Local indication for continuous supervision of the load on motor and installation.

- Load control: With the indication of the momentary temperature rise of the machine, the load on the installation can be continuously controlled to the maximum permissible temperature rise of the motor. The result is optimal utilization of the motor with full protection and maximum productivity of the driven installation.
- Automatic load control by a controller or inverter drive (e.g., for charging mills and crushers; the CET 4 itself is unable to protect inverter-driven motors).

Figure 3.27 Analog Output for Motor Temperature Rise

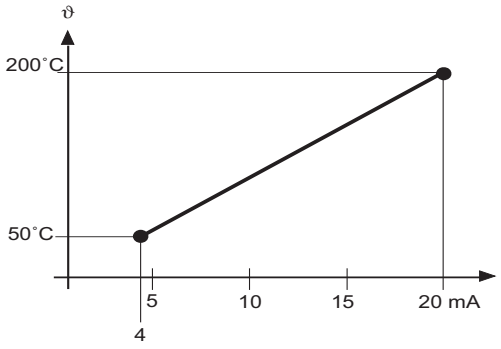


ϑ Temperature rise of motor
ϑ_{max} Permissible temperature limit (tripping threshold)
ϑ_G Nominal temperature (load I_e)
ϑ_K Coolant temperature (40 °C or via PT100 #7)

Thermal utilization calculation:

$$\text{Therm utiliz (\%)} = \frac{(\ldots \text{ mA} - 4 \text{ mA})}{16 \text{ mA}} \bullet 100\ \%$$

Figure 3.27.a Analog Output for Motor Temperature



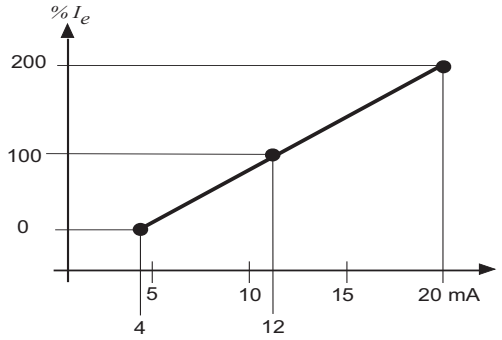
Motor Temperature calculation:

$$\text{Motor temp. (°C)} = \frac{(\ldots \text{ mA} - 4 \text{ mA})}{16 \text{ mA}} \bullet 200\ °C$$

3.5.5.2 Analog Output for Motor Current

The output supplies a current of 4 ... 20 mA proportional to the motor current.

Figure 3.27.b Analog Output for Motor Current



Motor current calculation:

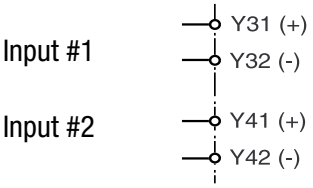
$$\text{Motor current } (\%I_e) = \frac{(\text{... mA - 4 mA})}{16\ \text{mA}} \bullet 200\ \%\ I_e$$

3.5.6 Control Inputs #1 and #2

With the control inputs #1 and #2, the following control and protection functions can be used:

- Timer functions
- Lock-out of protection functions
- Protection against stalling during starting with an external speedometer (see page 3-43)
- Changing over to a second rated current (two-speed motor)

Actuation



24 VAC or 24 VDC; 8 mA
Pick values:
On: 12 ... 36 V
Off: <2 V

The control inputs are galvanically separated from the electronic circuits by optocouplers. The control inputs are activated by applying 24 VAC or DC to Y31/Y32 or Y42/ Y42.
For further information see Chapter 9.

Timer Functions

The following functions can be programmed:

On Delay (t_{on}) 0 ... 240 sec.

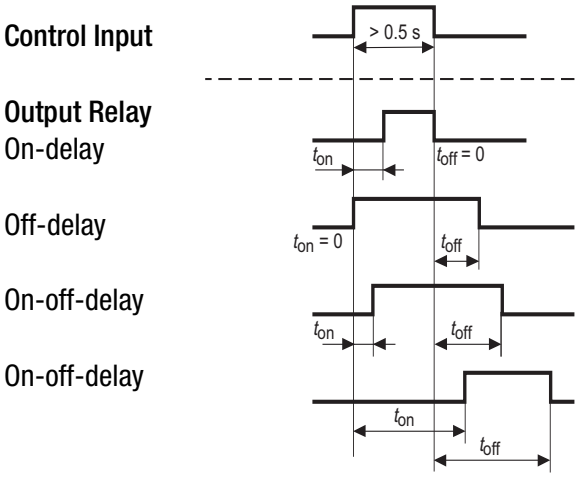
Off Delay (t_{off}) 0 ... 240 sec.

On and off delay 0 ... 240 sec.

Assignment of the Output Relays

- Control input #1 to output relay #2
- Control input #2 to output relay #3

Figure 3.28 Operating Diagram for Timer Functions



Applications

- Time-graded on and off setting
- Delaying the transfer of alarm and trip messages

Lock-out of Protection Functions

With control inputs #1 and #2, one or more protective functions can be locked out as desired.

- Asymmetry (phase unbalance)
- High overload/jam
- Earth (ground) fault
- Short-circuit
- Underload
- Limiting the number of starts/hour
- PTC
- PT100 (RTD)

Applications

Lock-out of protection functions

- During certain operational phases when the level differs from the normal values, such as:
  - during starting: earth fault and short-circuit protection
  - at no-load: protection against asymmetry and underload
  - during brief overload phases: high overload/jam
  - during commissioning and fault location (localizing the source of the trouble)

The selected functions are completely disabled as long as the control input is "on" (24 VAC/DC).

- No alarm
- No trip, no reset
- Tripping delays begin to run only after the function is re-enabled.

3.5.7 Switching to a Second Rated Current

In the CET 4, a second value can be selected for the rated current I_e. The change to the second rated value is controlled by activating control input #2 with 24 VAC/DC. Make sure the second rated current is compatible with the current range of the CWE 4 current converter module.

Application

- Two-speed motors
- Briefly increased loading of the motor and installation
- Maximum loading when the ambient temperature varies appreciably. Examples: Exposed water pumps, different conveying capacitie during daytime and at night.

3.6 Functions of CLV 4 Option Card

3.6.1 Phase Sequence

Function

If a motor is switched on in the wrong direction of rotation, the installation can be adversely affected. The CET 4 monitors the phase sequence when voltage is applied, and prevents the motor starting in the wrong direction.

Applications

- Mobile installations (e.g., refrigerated transporters, construction machines)
- Installations that can be displaced as enclosed units (e.g., mobile crushers, conveyor belts, saws)
- A reversed phase sequence must be expected after a repair.

Setting Parameter

Tripping Delay	
Factory Setting	1 sec.
Output Relay	
Selection (Relays)	MR, AL, #1 ... #5
Factory Setting	MR
Function	
Factory Setting	Off

ATTENTION: The phase sequence of the motor supply can be monitored only at the point of measurement (usually before the contactor). Exchanged leads between this point and the motor cannot be recognized.

3.6.2 Phase Failure (based Voltage Measurement)

Function

A phase failure is recognized by measuring the voltages before the switchgear and thus with the motor at standstill. (With phase failure protection where the phase currents are measured, the motor first has to be switched on, although it cannot start with only two phases.)

Setting Parameters

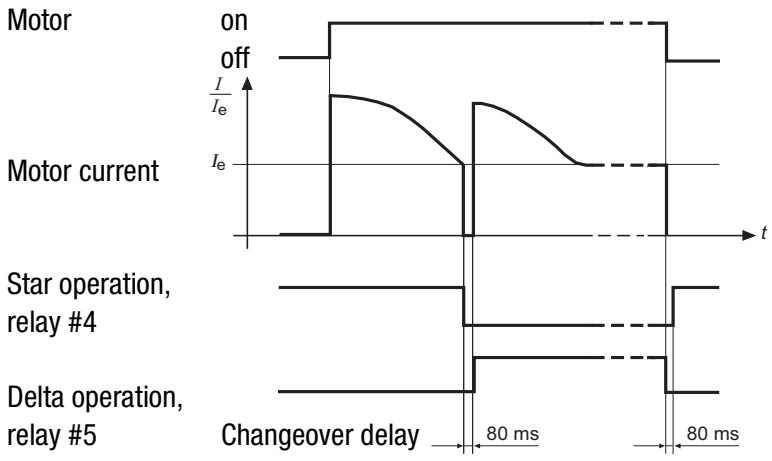
Tripping Delay	
Factory Setting	2 sec.
Output Relay	
Selection (Relays)	MR, AL, #1 ... #5
Factory Setting	MR
Function	
Factory Setting	Off

3.6.3 Star-Delta (Wye-Delta) Starting

The CET 4 issues the command to switch from star to delta (wye to delta) as soon as the starting current has dropped to the rated value and thus the motor has reached its normal speed in star (wye). If starting has not been completed within the normal time for this application [max. star (wye) operation], a change to delta will be made, regardless of the speed attained.

The permissible time for star (wye) operation can be switched on or off as desired. If it is off, the change to delta is made solely with reference to the motor current. If the motor has to be switched off when the normal starting time in star (wye) is exceeded, the function "monitoring starting time" must also be activated (see page 3-34).

Figure 3.29 Diagram of Star-Delta (Wye-Delta) Starting



Setting Parameters

Setting	Star (Wye) Relay	Delta Relay	Max. Star (Wye) Operation
Setting Range	–	–	1 ... 240 sec.
Factory Setting	Relay #4	Relay #5	10 sec.
Setting Steps	–	–	1 sec.
Function			
Factory Setting	–	Off	Off

3.7 Functions of CMV 4 Option Card

3.7.1 Temperature Sensor PT100, #1 ... #6 (RTD)

Especially in large motors, the temperature detectors PT100, #1 ... #6 are often embedded in the stator winding and/or the bearings. The CET 4 monitors the actual stator or bearing temperatures. Influences independent of the motor (high ambient temperature, obstructed cooling, etc.) are taken into account.
SWensors which are not connected must be switchoff!

For all detectors (#1 ... #6):

- The temperature is continuously indicated in °C
- The alarm and tripping temperatures can be set as desired

Applications

- Large low voltage motors
- Medium/high-voltage motors
- At high ambient temperatures
- When cooling is obstructed.

Setting Parameters

	Warning	Trip
Response Level		
Setting Range	50 ... 200 °C	50 ... 200 °C
Factory Setting	–	50 °C
Setting Steps	–	1 °C
Tripping Delay		
Factory Setting	< 8 sec.	< 8 sec.
Output Relay		
Selection (Relays)	AL, #1 ... #3	MR, AL, #1 ... #3
Factory Setting	AL	MR
Function		
Factory Setting	Off	–

ATTENTION: The response level for "Warning" must be lower than the level for "Trip."

3.7.2 Temperature Sensor PT100, #7 (RTD)

The PT100, #7 measures the ambient temperature or the coolant in the motor and indicates it in degrees Celsius. The CET 4 takes into account the temperature of the coolant in the thermal image. The motor and the installation can be better utilized with deviating coolant temperatures.

PT100 PROT
ON

The temperature of the coolant/ambient temperature is indicated as soon as the function is activated and PT100, #7 is connected.

LCD of CET 4:

Tambient ... °C

So that the coolant temperature may be taken into account in the thermal image, this function must be activated:

Tamb IN TH IMAGE
ON

Ambient temperature in thermal image is taken into account.

MOTOR INSULATION CLASS
B

Insulation class of winding

Setting Parameters

Insulation Class	
Selection	B, E, F
Factory Setting	B
Function	
Factory Setting	Off

Application

- With large temperature variation (day/night)
- Outdoor installations:
  - Pumps
  - Conveyors
  - Crushers
  - Saws

4.1 Overview

This chapter contains the following sections:

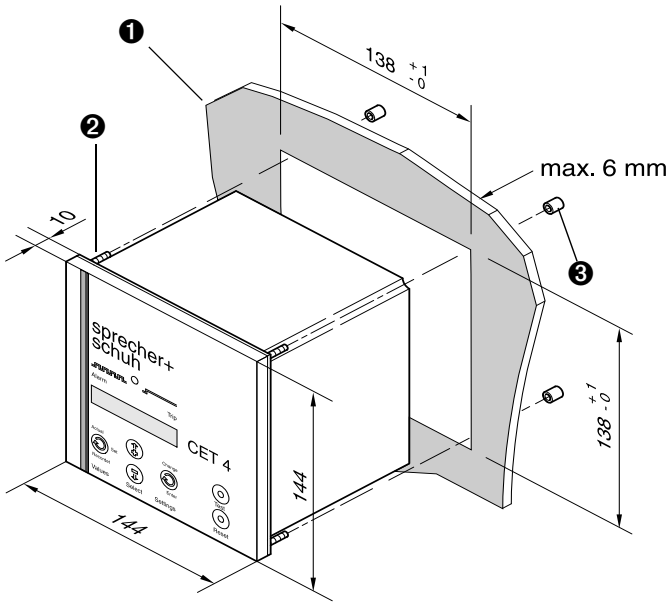
Section	Page
Assembly	**4-1**
CET 4 for Flush Mounting	4-1
Mounting Position	4-2
CET 4 for Surface Mounting	4-2
Converter Modules CWE 4-2.5, CWE 4-20 and CWE 4-180	4-3
Converter Modules CWE 4-630, CWE 4-630N	4-3
Indication Instrument CUD 4 for Thermal Utilization	4-4
Installation and Wiring	**4-5**
General	4-5
Main Circuits	4-5
Control Circuits	4-7

4.2 Assembly

4.2.1 CET 4 for Flush Mounting

To mount the CET 4 in a front panel, cut a rectangular hole with the following dimensions.

Figure 4.1 CET 4 Mounted in a Cabinet

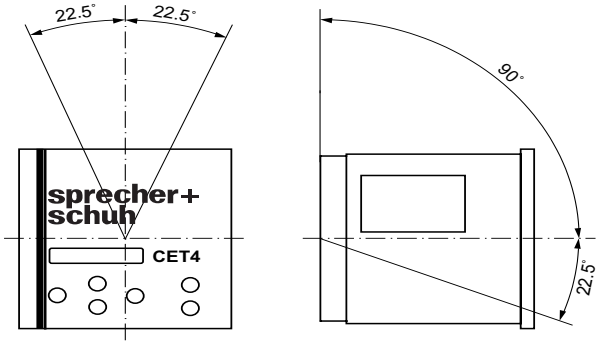


Dimensions in mm (inches)
Dimensions:
Panel cutout: 138 x 138 mm
(-0 mm, +1 mm)
Mounting depth: min. 140 mm

❶ Front panel with cutout
❷ Rubber gasket
❸ Fixing nuts

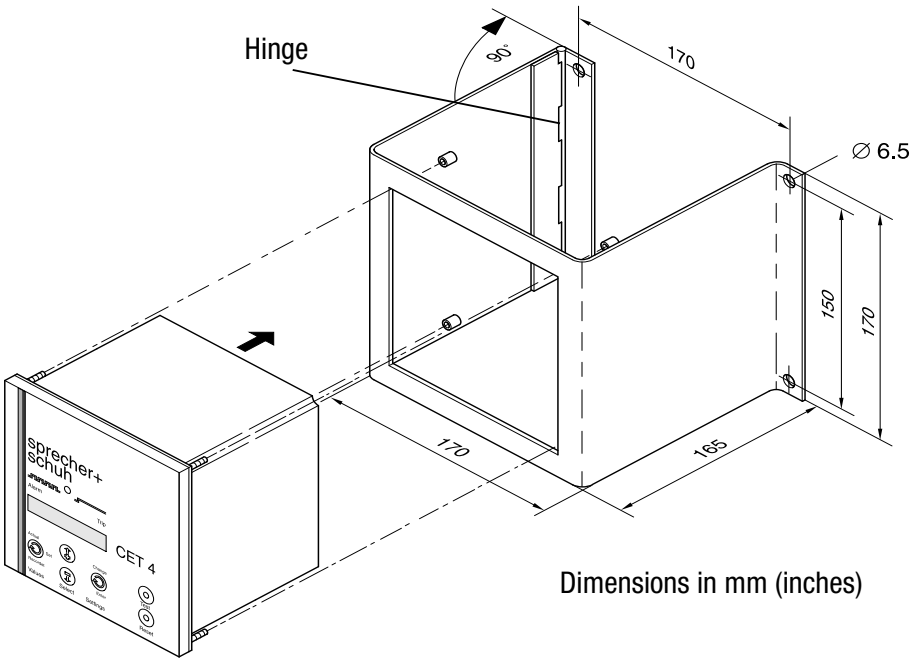
4.2.2 Mounting Position

Figure 4.2 CET 4 Mounting Position



4.2.3 CET 4 for Surface Mounting

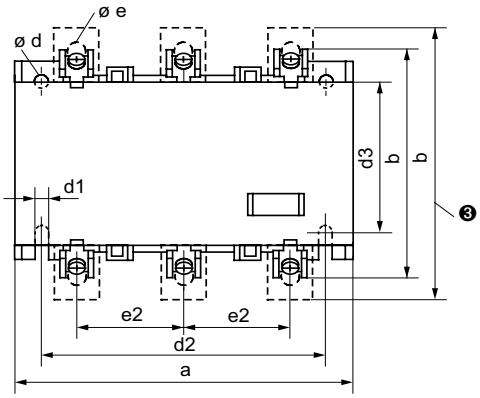
Figure 4.3 CET 4 Mounted into Panel Mounting Frame CET 4-FPM

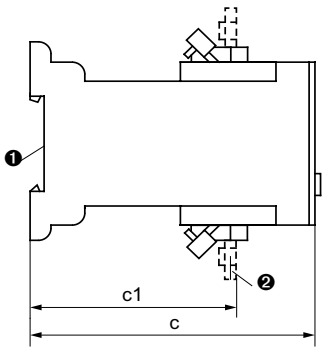


Dimensions in mm (inches)

4.2.4 Converter Modules CWE 4-2.5, CWE 4-20, and CWE 4-180

Figure 4.4 CWE 4-2.5, CWE 4-20, CWE 4-180





❶ Mounted on DIN-rail EN 50 022-35

❷ Bus bar or opening for conductor max. ∅ 19 mm

❸ With CWE 4-VM

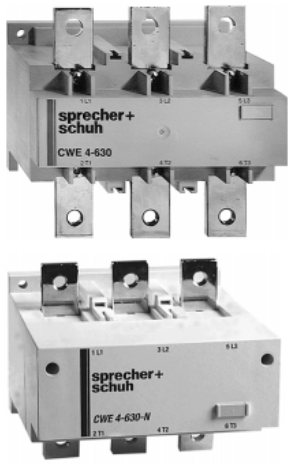
❹ With CWE 4-VM2

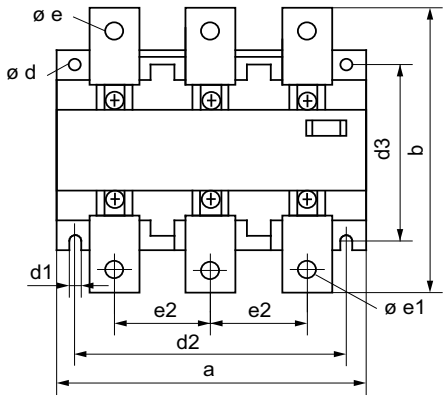
Dimensions in millimeters (inches).

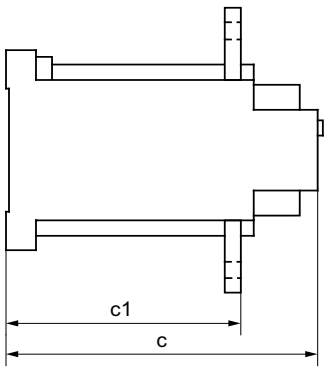
CWE	a	b	c	c1	∅ d	d1	d2	d3	∅ e	∅ e1	e2	b1	b2
4-2.5	120 (4-45/64)	85 (3-23/64)	102 (4)	66 (2-39/64)	5.3 (3/16)	5.3 (3/16)	100 (3-7/8)	55 (2-3/16)	2 x 2.5 mm^2	–	38.5 (1-1/2)		
4-20	120 (4-45/64)	85 (3-23/64)	102 (4)	66 (2-39/64)	5.3 (3/16)	5.3 (3/16)	100 (3-7/8)	55 (2-3/16)	2 x 2.5 mm^2	–	38.5 (1-1/2)		
4-180	120 (4-45/64)		102 (4)	72 (2-13/16)	5.3 (3/16)	5.3 (3/16)	100 (3-7/8)	55 (2-3/16)	M8	M8	38.5 (1-1/2)	75 (2-61/64)	❸ / ❹ 100/118

4.2.5 Converter Modules CWE 4-630, CWE 4-630N

Figure 4.5 CWE 4-630, CWE 4-630N





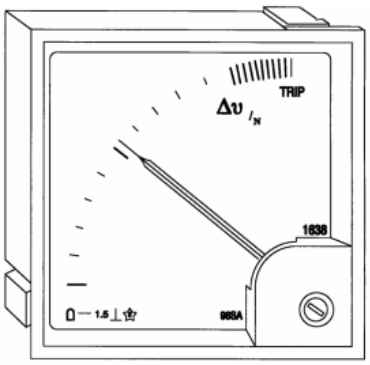


Dimensions in millimeters (inches).

	a	b	c	c1	∅ d	d1	d2	d3	∅ e1	e2
CWE 4-630	155 (6-7/64)	145 (5-11/16)	156 (6-1/8)	118 (4-5/8)	6.3 (1/4)	6.3 (1/4)	135 (5-5/16)	88 (3-7/16)	M10	48 (1-7/8)
CWE 4-630N	155 (6-7/64)	145 (5-11/16)	177 (6-31/32)	118 (4-5/8)	6.3 (1/4)	6.3 (1/4)	135 (5-5/16)	88 (3-7/16)	M10	48 (1-7/8)

4.2.6 Indication Instrument CUD 4 for Thermal Utilization

Figure 4.7 Indication Instrument CUD 4



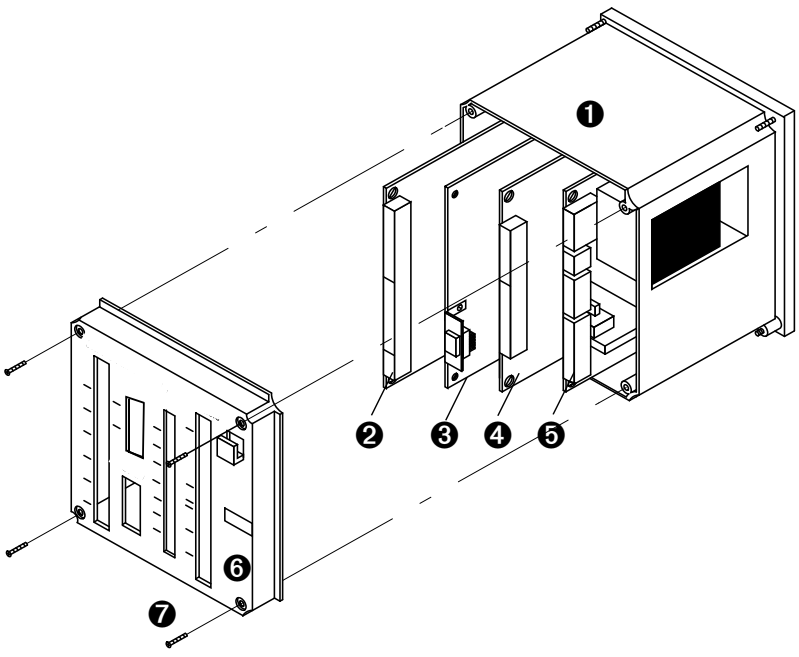
Panel cutout: 91.5 x 91.5 mm (3-39/64“ x 3-39/64“) (-1 mm [-1/16“] + 0.5 mm [+1/32“])

Mounting depth: 55 mm (2-3/16“)

Wire size: 2 x 2.5 mm^2 (AWG No.14)

ATTENTION: To retrofit options or to replace them, the assembly and testing instructions supplied with the option must be strictly complied with.

Figure 4.8 CET 4 Housing with Option Cards



❶ CET 4-housing
❷ Option CMV 4 or CLV 4
❸ Communication board
❹ Option CST 4
❺ Board with basic unit
❻ Rear cover
❼ Screws

4.3 Installation and Wiring

4.3.1 General

The CET 4 electronic motor protection device fulfills the stringent requirements imposed by global standards requirements regarding electromagnetic compatibility (EMC). This means that there is no need to observe any special stipulations when wiring the CET 4.

Nevertheless, control leads should be laid separately from power leads. In the circuit diagrams throughout this section, any special wiring requirements are specifically noted.

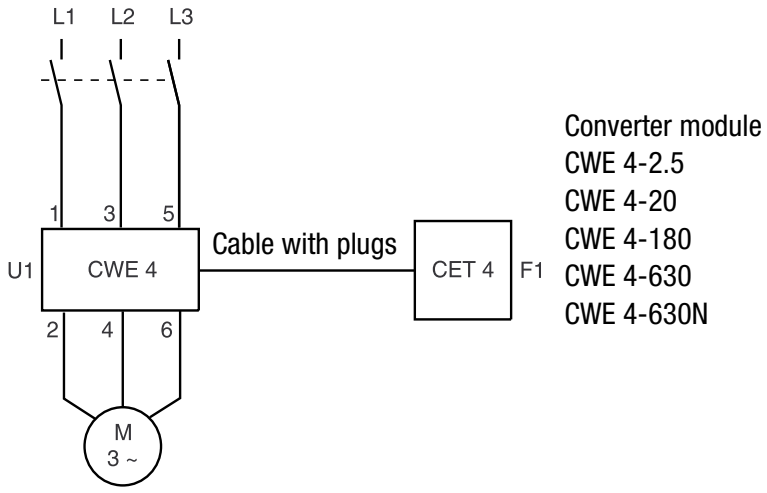
The data of the output circuits and control inputs are dealt with in Chapter 2, *Technical Data*. Throughout this manual, the contacts of the output relays are shown in their normal working position (i.e., the CET 4 control voltage is switched on, no warning, no trip).

ATTENTION: All assembly and installation work must be performed by qualified personnel, taking local codes into account.

4.3.2 Main Circuits

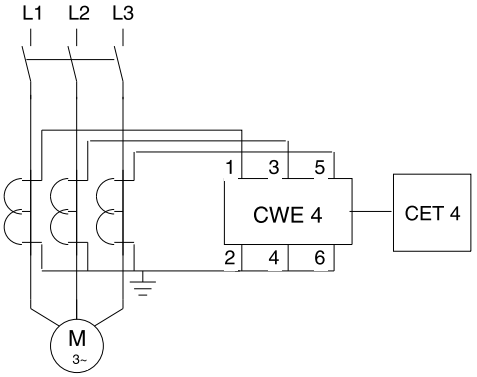
CET 4 and CWE 4 without Main Current Transformer

Figure 4.9 CET 4 with Converter Module



CET 4 and CWE 4 with Main Current Transformer

Figure 4.10 Current Evaluation Three-phase

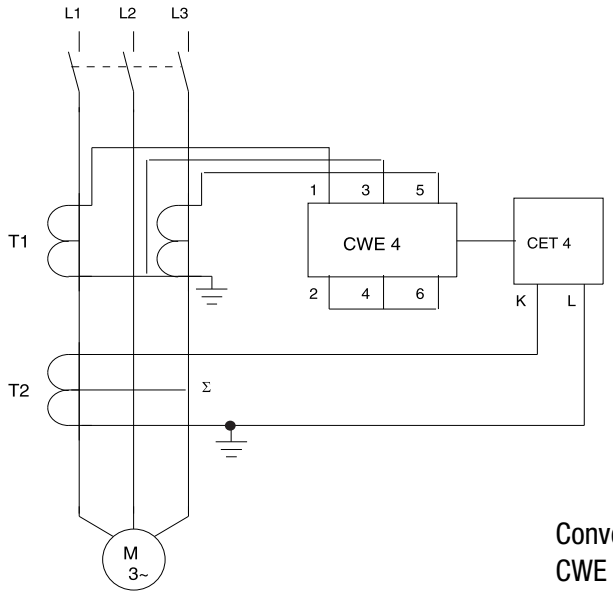


Converter module
CWE 4-2.5
CWE 4-20

Main current transformer
...A/5 A or ... A/1 A
For selection see chapter 2

CET 4 and CWE 4 with Main and Core Balance Current Transformer

Figure 4.11 Current Evaluation Two-phase



Converter module
CWE 4-2.5
CWE 4-20

Main current transformer ...A/5 A or ... A/1 A
For selection see chapter 2

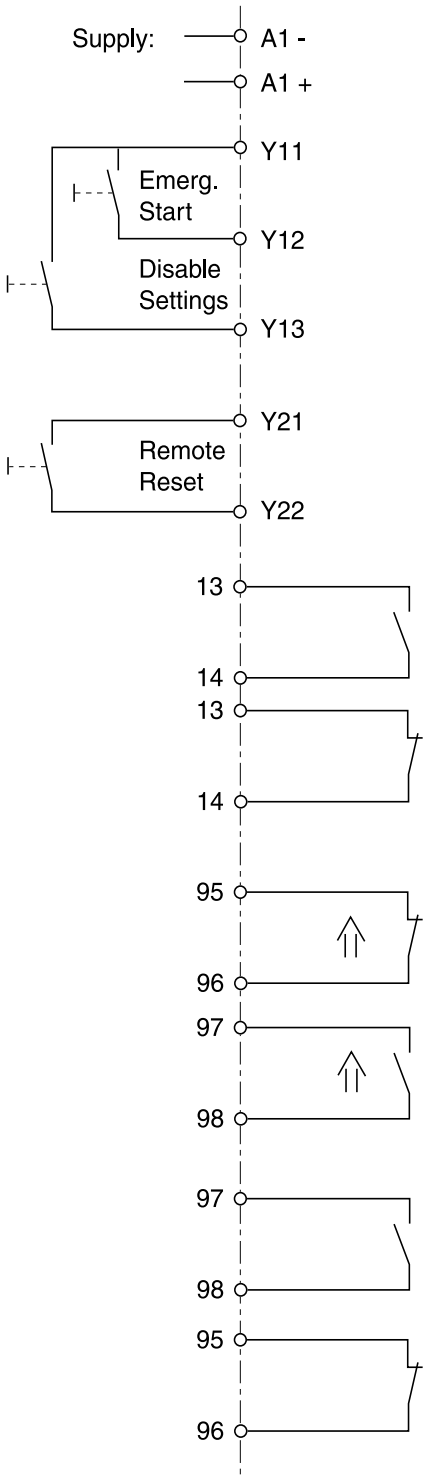
Core balance current transformer:

Earth-/Ground Current	5 mA ... 50 A
Current ratio of core balance c.t.	1 ... 2 000:1
Output from core balance c.t.	0 ... 500 mA

More circuit diagrams can be found in Chapter 9.

4.3.3 Control Circuits

Basic Unit CET 4



Supply AC or DC
No fuse needed

Emergency override of thermal trip
(Emergency start): Push button, key-switch
Disable settings and keys : ❶Wire jumper, switch, key-switch

Remote reset: ❷
Push button, key-switch

Alarm relay AL, non-fail-safe connection (Factory setting)
IEC 400 VAC/125 VDC
UL/CSA240 VAC/125 VDC

Alarm relay AL, fail-sfe (electrically held) connection (from V2.18, selectable)
IEC 400 VA/125 VDC
UL/CSA240 VAC/125 VDC

Output relay MR in fail-safe (electrically held) connection
(Factory setting)
IEC 400 VAC/125 VDC
UL/CSA240 VAC/125 VDC

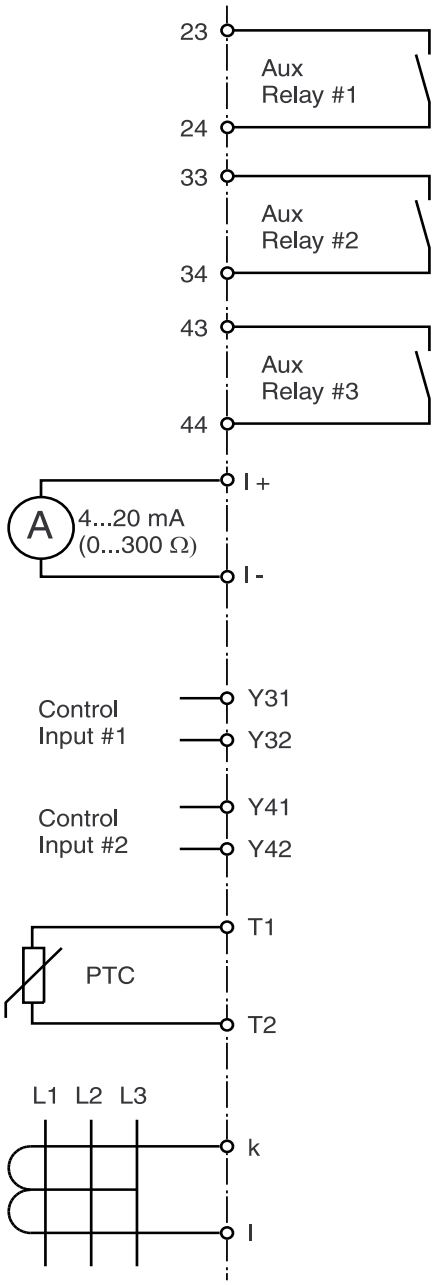
Output relay MR in non-fail-safeconnection
IEC 400 VAC/125 VDC
UL/CSA240 VAC/125 VDC

External **Internal**

❶ Setting via communication is also disabled, as well as Test and Reset

❷ The remote reset is always active

CST 4 Option Card



Auxiliary relay #1	IEC 400 VAC/125 VDC UL/CSA240 VAC/125 VDC
Auxiliary relay #2	50 VAC/30 VDC ❶
Auxiliary relay #3	50 VAC/30 VDC ❷

Analog output indicates the thermal utilization of the motor, or the motor temperature, or the motor current.

- Indicating instrument
- PLC input
- Recorder

Control input #1: 24 VDC or 24 VAC ❶

Control input #2: 24 VDC or 24 VAC ❷

Thermistor overtemperature protection max. 6 PTC wired in series
Measuring lead ❶

Min. cross-section [mm^2]		0.5	0.75	1	1.5	2.5
	[AWG No.]	20	18	17	16	14
Max. length	[m]	200	300	400	600	1 000
	[ft.]	656	984	1 312	1 968	3 280

Core balance transformer 5 ... 500 mA at k-l

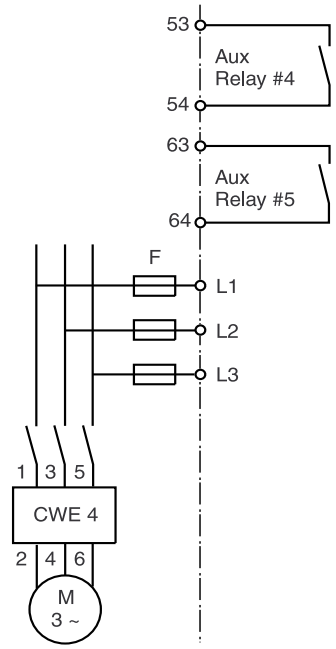
External **Internal**

❶ Method of installation: up to 100 m (328 ft.) twisted, unscreened

❷ Methods of actuaction, see chapter 9.

CLV 4 Option Card

ATTENTION: Either the option CLV 4 or CMV 4 may be inserted in this position.



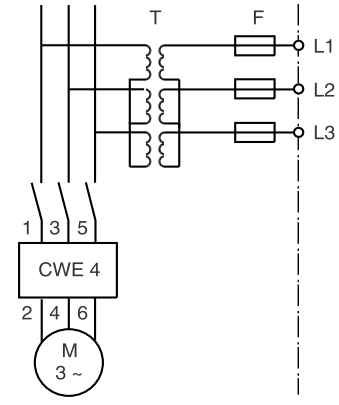
External Internal

Auxiliary relay #4
IEC 400 VAC/125 VDC
UL/CSA 240 VAC/125 VDC

Auxilary relay #5
IEC 400 VAC/125 VDC
UL/CSA 240 VAC/125 VDC

Phase sequence protection
Phase failure protection

- as per IEC, SEV 110 ... 400 VAC
- as per UL, CSA 110 ... 240 VAC

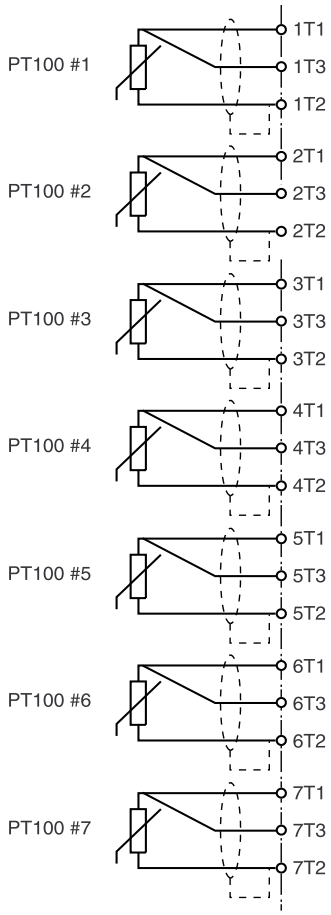


External Internal

Supply voltage >400 VAC
(UL, CSA >240 VAC)

CMV 4 Option Card

ATTENTION: Either the option CLV 4 or CMV 4 may be inserted in this position.



PT100 inputs #1 ... #6 (RTD) for monitoring the temperature of the stator winding and motor bearings.

PT100, #7 for indication and inclusion of the coolant/ambient temperature (cooling air) in the thermal image. If the PT100 #7 is not connected, then it must be switched off.

Tamb IN TH IMAGE
OFF

Method of installation:

- Short links (up to 10 m) laid separate from power cables need no screening.
- Longer leads must be screened/shielded

  -Separately screened: connect screens to individual T2 (ex. 1T2, 2T2. . .)

  -Common screening: connect screen to T2, and all T2 together (ex. 1T2, 2T2. . .)

Option Communication

ATTENTION: Only one of the following options can be inserted at one time.

Bulletin 825-MDN for DeviceNet Connection

Refer to 41053-099-01
For more DeviceNet components see Publication B112

3600-RIO for RI/O Connection

Refer to ProSoft 3600-RIO User Manual

3600-MBS for Modbus Connection

Refer to ProSoft 3600-MBS User Manual

CPB 4 for PROFIBUS Connection

Refer to Publication 825-5.1 for further information regarding PROFIBUS.

CPC 4 for PROFIBUS Connection in a PC

Refer to Publication 825-5.2 for further information on VISU software.

Chapter 5 Setting the Operational Parameters

5.1 Overview

This chapter contains the following sections:

Section	Page
Menu Overview	5-2
SET VALUES	5-2
Main Settings	5-3
Special Settings	5-4
Operating Parameters	5-5
CET 4	5-5
CST 4 Option Card	5-10
CLV 4 Option Card	5-14
CMV 4 Option Card	5-15
Communication Board	5-17
Relay Control	5-17
Clear Recorded Values	5-18
Reset Settings to Factory Settings (Default Values)	5-18

With the four operating keys on the front of the unit, all operating parameters can easily be set or altered at any time. The procedure is described in Chapter 3.

ATTENTION: All parameters can be set,including functions of option boards that are not mounted therefore. These warning- and trip functions are not operational!

5.2 Menu Overview

5.2.1 SET VALUES

Parameter List	Option	Page
THERMAL PROTECTION		5-3, 5-5
THERMAL PROTECTION WARNING		5-6
ASYMMETRY PROTECTION TRIP		5-6
ASYMMETRY PROTECTION WARNING		5-6
OVERCURRENT PROTECTION TRIP		5-7
OVERCURRENT PROTECTION WARNING		5-7
EARTH FAULT PROTECTION		5-7
EARTH FAULT HOLMGREEN TRIP		5-7
EARTH FAULT CORE TRIP	CST 4	5-10
EARTH FAULT CORE WARNING	CST 4	5-10
SHORT CIRCUIT PROTECTION	CST 4	5-11
UNDERLOAD PROTECTION TRIP		5-8
UNDERLOAD PROTECTION WARNING		5-8
STAR DELTA STARTING	CLV 4	5-14
WARM STARTING		5-8
START INHIBIT		5-9
START CONTROL		5-9
MAIN RELAY CONNECTION		5-9
ALARM RELAY CONNECTION		5-9
THERMAL RESET		5-9
THERMAL RESET LEVEL		5-9
COOLING CONSTANT RATIO		5-4, 5-9
PTC PROTECTION TRIP	CST 4	5-11
PTC RESET	CST 4	5-11
CONTROL INPUT #1	CST 4	5-11
DELAY AUX RELAY 2		5-11
SPEED SWITCH		5-12
DISABLE FUNCTION		5-12
CONTROL INPUT #2	CST 4	5-13
DELAY AUX RELAY 3		5-13
NEW FULL LOAD CURRENT		5-13
DISABLE FUNCTION		5-13
PHASE REVERSAL PROTECTION TRIP	CLV 4	5-14
PHASE LOSS PROTECTION TRIP	CLV 4	5-14
PT100 PROTECTION	CMV 4	5-15
PT100 RESET		5-16
PT100 WARNING		5-17
OUTPUT 4 … 20 mA	CST 4	5-17
STATION NUMBER		5-3, 5-17
BAUD RATE		5-3, 5-17
REL #2-3 VIA COM		5-17
CLEAR RECORDED VALUES		5-18
FACTORY SETTINGS		5-18

5.3 Main Settings

The main settings have to be individually set for each motor.

Parameter	Setting Range	Factory Setting
Rated motor current or service current I_e	0.5 ... 2 000 A	20 A
Current ratio of primary current transformer	1 ... 2 000	1
Locked-rotor current	2.5 ... 12 I_e	6 I_e
Locked-rotor time ❶	1 ... 600 sec.	10 sec.

❶ If instead of the permissible locked-rotor time the maximum starting time is known, the approximate locked-rotor time is calculated as follows:

$$\text{Locked-rotor time: } \approx \frac{\text{Starting time}}{1.4}$$

All other parameters, such as Overcurrent, Underload, Asymmetry, etc., are set in the factory to values that are correct for the majority of applications. These factory-set values can be changed if requirements differ. The same applies to Special Settings.

5.4 Special Settings

Parameter	Setting Range	Factory Setting
Connection of main relay (MR)	Electrically held / non-fail-safe	Electrically held
Reset of thermal trip	Manual/auto	Manual
Reset at . . .% thermal utilization	10 ... 100 %	50 %
Reset PTC trip	Manual/auto	Manual
Cooling constant ratio motor on/off	1 ... 5	2.5
Motor insulation class ❶	B, E, F	B

❶ Motor insulation class needs to and can be set only if PT100 #7 (RTD) is included in the thermal image.

ATTENTION: Do not exceed the permissible values quoted by the motor manufacturer.

Communication	Setting Range	Factory Setting
DeviceNet		
Station number	0 ... 63	2
Baud rate: 125 / 250 / 500 kbaud	0 ... 2	4
Remote I/O		
Station number	0 ... 63	2
Baud-Rate ❷	0 ... 23	4
Baud-Rate ❸	0 ... 118	5
PROFIBUS		
Station number,	1 ... 126	2
Baud-Rate 9.6 / 19.2 / 73.75 / 187.5 / 500 kbaud	0 ... 4	4 (500 kbd)
Modbus		
Station number	0 ... 247	2
Baud-Rate ❹	0 ... 182	4
Baud-Rate ❸	0 ... 118	5

❷ **Baud-Rate for Remote I/O**

Calculated according to the following formula:
Value = (8 x baud) + (4 x last_rack) + starting_mod_group
Baud: 0 = 57.6 kbaud, 1 = 115.2 kbaud, 2 = 230.4 kbaud
last_rack: 0 = no, 1 = yes
starting_mod_group: 0 = group 0, 1 = group 2, 2 = group 4, 3 = group 6

The rack_size is fixed to 1/4 rack.

❸ **Baud-Rate for DF1**

Calculated according to the following formula:
Value = (64 x mode) + (32 x stop_bits) + (8 x parity) + baud
Mode: Data protection : 0 = CRC, 1 = BCC
stop_bits: 0 = 1 stop bit, 1 = 2 stop bit
parity: 0 = none, 1 = odd, 2 = even
baud: 0 = 300 baud, 1 = 600 baud, 2 = 1 200 baud, 3 = 2 400 baud, 4 = 4 800 baud, 5 = 9 600 baud, 6 = 19 200 baud

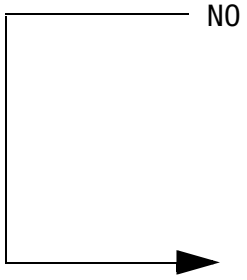
❹ **Baud-Rate for Modbus**

Calculated according to the following formula:
Value = (64 x mode) + (32 x stop_bits) + (8 x parity) + baud
Mode: Protocol: 0 = RTU, 1 = ASCII 7 bit, 2 = ASCII 8 bit
stop_bits: 0 = 1 stop bit, 1 = 2 stop bit
parity: 0 = none, 1 = odd, 2 = even
baud: 0 = 300 baud, 1 = 600 baud, 2 = 1 200 baud, 3 = 2 400 baud, 4 = 4 800 baud, 5 = 9 600 baud, 6 = 19 200 baud

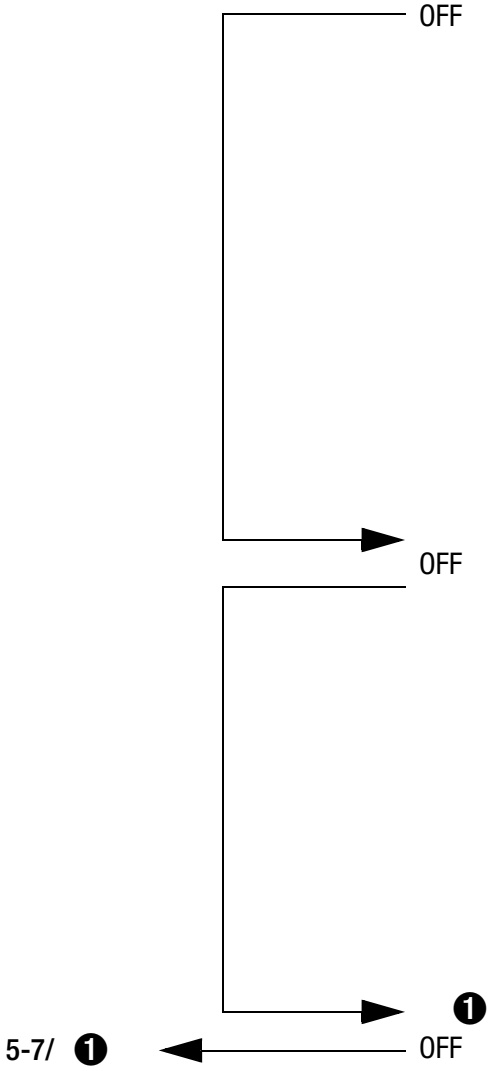
5.5 Operating Parameters

5.5.1 Bulletin 825-M*

Main Settings



LCD	Setting Range	Description
SET VALUES	–	Mode: Set parameters
FULL LOAD CURR 20 A	0.5 ... 2 000	Rated motor current in A
PRIMARY C.T. #1 NO	No/Yes	Use of the first primary transformer
PRIM. C.T. RATIO 1	1 ... 2 000	Current ratio of the primary current transformer e.g. 500 A/5 A, setting = 100 800 A/5 A, setting = 160
LOCKED ROT CURR 6 x Ie	2.5 ... 12	Locked rotor and starting current in . . . I_e
LOCKED ROT TIME 10 sec	1 ... 600	Maximum permissible locked-rotor time of motor from cold



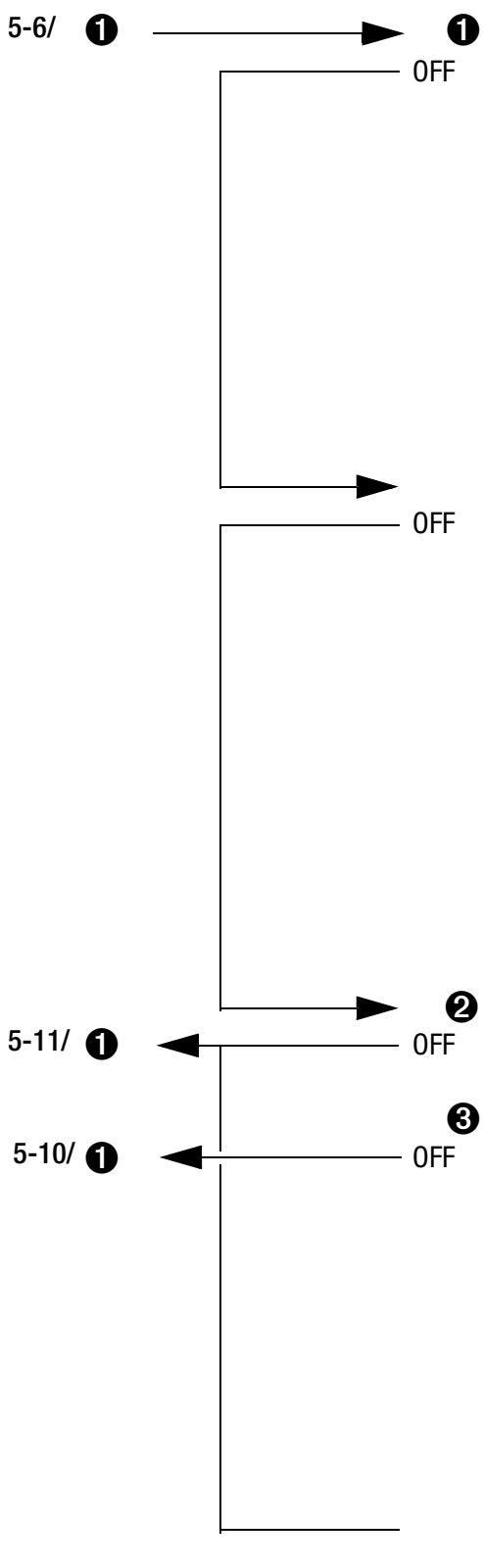
Thermal Overload

LCD	Setting Range	Description
THERMAL TRIP MAIN RELAY	Main relay/ no relay	Thermal trip, motor Choice between main output relay and no relay
THERMAL WARNING OFF	On/Off	Thermal warning (motor temp) On/Off
TH WARNING LEVEL 75 %	50 ... 99	Pickup value for thermal warning temperature rise as percent of thermal utilization
TH WARNING ALARM RELAY	All except main relay	Thermal warning Assignment of output relay

Asymmetry (Phase Unbalance)

LCD	Setting Range	Description
ASYMMETRY TRIP ON	On/Off	Asymmetry protection (current measuring asymmetry) On/Off
AS TRIP LEVEL 35 %	5 ... 80	Asymmetry trip Tripping level in percent
AS TRIP TIME 2.5 sec	1 ... 25	Asymmetry trip Tripping delay
ASYMMETRY TRIP MAIN RELAY	All relays	Asymmetry trip Assignment of relays
AS WARNING OFF	On/Off	Asymmetry warning On/Off
AS WARNING LEVEL 20 %	5 ... 80	Asymmetry warning Warning level in percent
AS WARNING ALARM RELAY	All except main relay	Asymmetry warning Assignment of output relay

ATTENTION: Ensure that trip function is reset before it is inactivated.

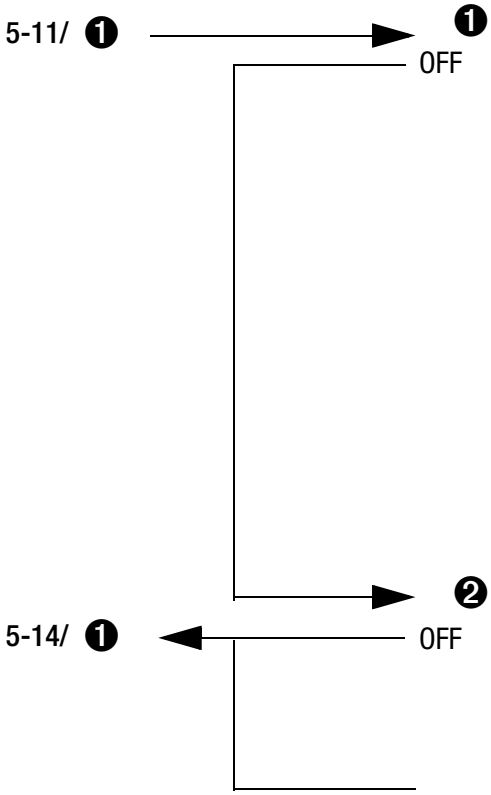


Overcurrent

LCD	Setting Range	Description
OVERCURR TRIP ON	On/Off	Overcurrent/locked-rotor protection On/Off
OC TRIP LEVEL 2.4 x Ie	1.0 ... 6.0	Overcurrent/locked-rotor Tripping level in . . . I_e
OC TRIP TIME 0.5 sec	0.1 ... 5	Overcurrent/locked-rotor Tripping delay
OVERCURRENT TRIP MAIN RELAY	All relays	Overcurrent/locked-rotor Assignment of output relay
OC WARNING OFF	On/Off	Overcurrent/locked-rotor warning On/Off
OC WARNING LEVEL 2.0 x Ie	1.0 ... 6.0	Overcurrent/locked-rotor Warning level in . . . I_e
OC WARNING ALARM RELAY	All except main relay	Overcurrent/locked-rotor warning Assignment of output relay

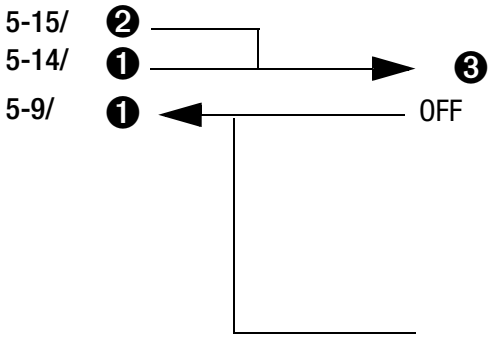
Earth (Ground) Fault (Holmgreen / Residual)

LCD	Setting Range	Description
EARTH FAULT PROT ON	On/Off	Earth (ground) fault protection On/Off
EF HOLMG TRIP ON	On/Off	Earth (ground) fault protection (Holmgreen = Residual) On/Off
EF H TRIP LEVEL 50 %	10 ... 100	Earth (ground) fault trip (Holmgreen = Residual Tripping level, percent of motor current
EF H TRIP TIME 0.50 sec	0.1 ... 5	Earth (ground) fault trip (Holmgreen = Residual) Tripping delay
EF HOLMG TRIP MAIN RELAY	All relays	Earth (ground) fault trip (Holmgreen = Residual) Assignment of output relay



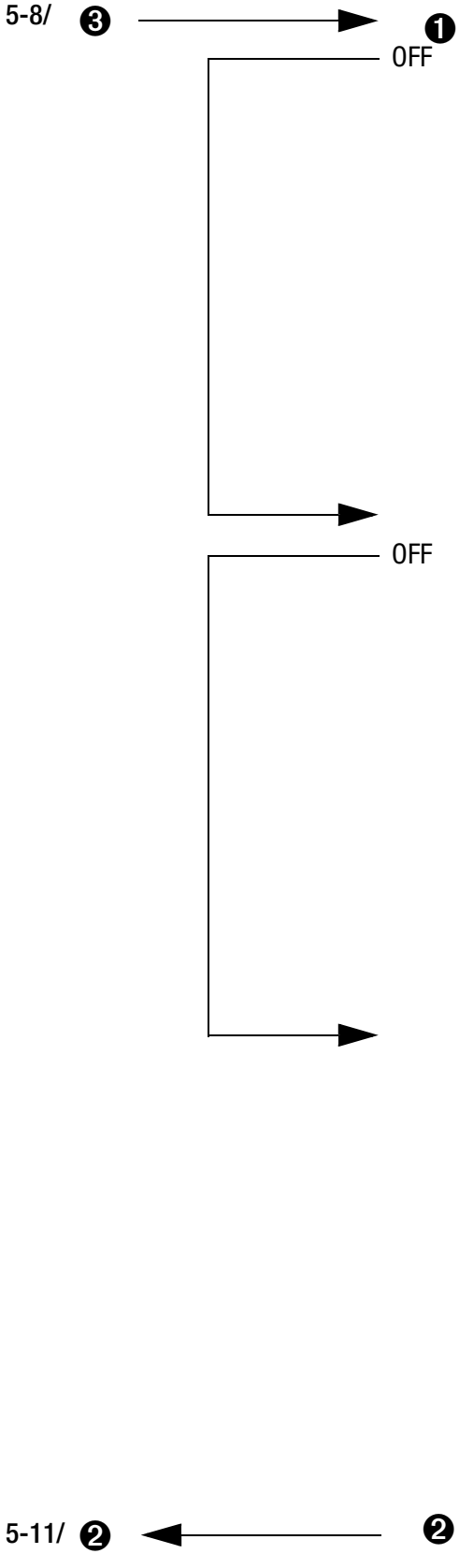
Underload

LCD	Setting Range	Description
UNDERLOAD TRIP OFF	On/Off	Underload protection On/Off
UL TRIP LEVEL 75 % Ie	25 ... 100	Underload trip Tripping level . . . % I_e
UL TRIP TIME 10 sec	1 ... 60	Underload trip Tripping delay
UNDERLOAD TRIP MAIN RELAY	All relays	Underload trip Assignment of output relay
UL START-DELAY 0 sec	0 ... 240	Underload trip Start delay
UL WARNING OFF	On/Off	Underload warning On/Off
UL WARNING ALARM RELAY	All except main relay	Underload warning, assignment of output relay (warning level is equal to tripping level, without tripping delay)



Warm Start

LCD	Setting Range	Description
WARM STARTING OFF	On/Off	Warm start On/Off
WARM START EACH 60 min	4 ... 60	Warm start possible every . . . min
WARM TRIP TIME 70 %	50 ... 100	Warm start tripping time as a percentage of tripping time from cold



Limiting Number of Starts per Hour

LCD	Setting Range	Description
START INHIBIT OFF	On/Off	Limiting number of starts/ hour On/Off
MAX START/HOUR 2	1 ... 10	Maximum starts/hour
START INHIB TRIP MAIN RELAY	All relays	Maximum number of starts/hour reached Assignment of output relay

Monitoring Start-up Time

LCD	Setting Range	Description
START CONTROL OFF	On/Off	Monitoring starting time On/Off
START TIME 10 sec	1 ... 240	Maximum starting time
START CONT TRIP MAIN RELAY	All relays	Starting time exceeded Assignment of output relay

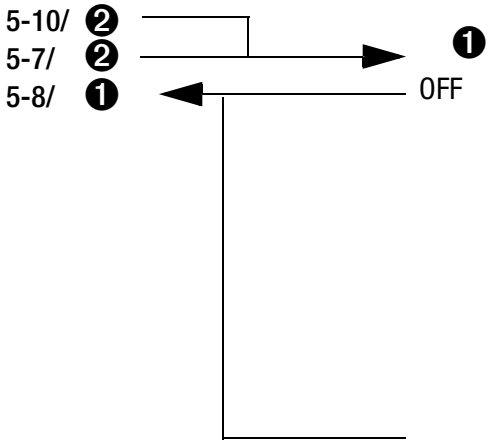
Special Settings

LCD	Setting Range	Description
MAIN RELAY ELECTR. HELD	electri-cally held / non-fail-safe	Main output relay in electrically held or non-fail-safe connection
ALARM RELAY NON-FAIL-SAFE	electri-cally held / non-fail-safe	Alarm relay in non-fail-safe or electrically held connection
TH TRIP RESET MANUAL	Manual/ auto	Reset of thermal trip Manual/automatic
THE RESET LEVEL 50 %	10 ... 100	Thermal reset at . .% of thermal utilization
COOL-CONST RATIO 2.5	1.0 ... 5.0	Cooling constant ratio between "motor off" and "motor on"

5.5.2 Bulletin 825-MST Option Card

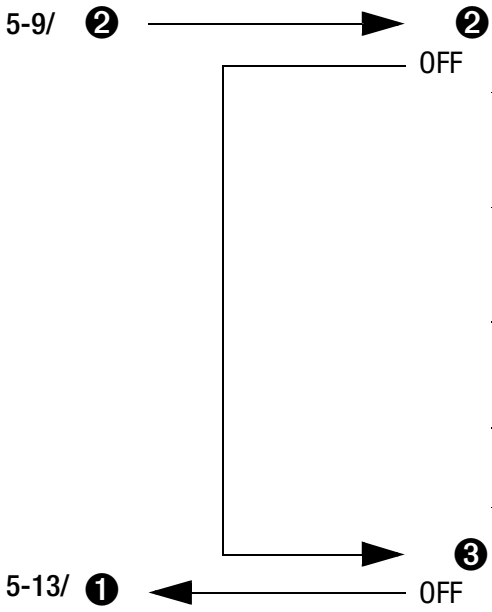
Earth (Ground) Fault

LCD	Setting Range	Description
EF CORE TRIP OFF	On/Off	Earth (ground) fault protection (core balance transformer) On/Off
CORE C.T. RATIO 1	1 ... 2 000	Core balance transformer current ratio
EF C TRIP LEVEL 1 A	5… 999 mA 1.00 … 50.00 A	Earth (ground) fault trip (core balance transformer) Tripping level
EF C TRIP TIME 0.50 sec	0.1 ... 5	Earth (ground) fault trip (core balance transformer) Tripping delay
EF CORE TRIP MAIN RELAY	All relays	Earth (ground) fault warning (core balance transformer) Assignment of output relay
EF C WARNING OFF	On/Off	Earth (ground) fault warning (core balance transformer) On/Off
EF C WARN LEVEL 500 mA	5… 999 mA 1.00 … 50.00 A	Earth (ground) fault warning (core balance transformer) Tripping level
EF C WARNING ALARM RELAY	All except main relay	Earth (ground) fault warning (core balance transformer)



Short Circuit

LCD	Setting Range	Description
SHORT CIRC TRIP OFF	On/Off	Short-circuit protection On/Off (h.v. motors only)
SC TRIP LEVEL 10.00 x Ie	4.0 ... 12.0	Short-circuit trip Tripping level . . . I_e
SC TRIP TIME 50 ms	20 ... 990	Short-circuit trip Tripping delay
SHORT CIRC TRIP AUX RELAY #1	Relay #1/ no relay	Short-circuit trip, choice between output relay #1 and no relay

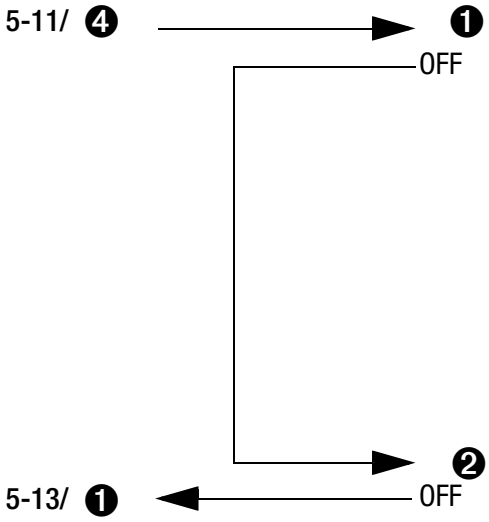


PTC Temperature Sensors

LCD	Setting Range	Description
PTC TRIP ON	On/Off	Thermistor protection PTC On/Off
PTC TRIP MAIN RELAY	All relays	PTC trip Assignment of output relay
PTC RESET MANUAL	Manual/ auto	Reset PTC trip Manual/automatic

Control Input #1

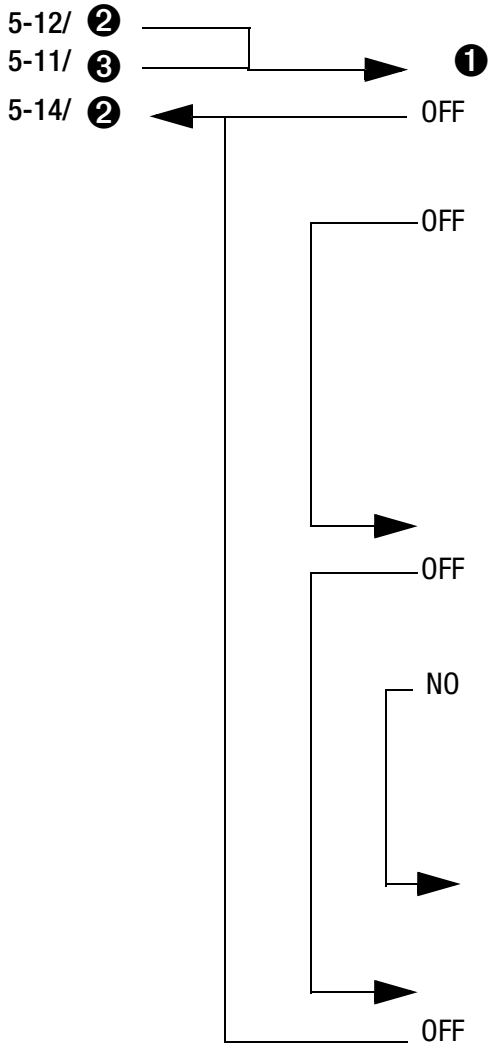
LCD	Setting Range	Description
CONTROL INPUT #1 OFF	On/Off	Control input #1 On/Off
DELAY AUX REL #2 OFF	On/Off	Timer function of output relay #2 On/Off
ON DELAY AUX #2 1 sec	0 ... 240	On-delay of output relay #2
OFF DELAY AUX #2 2 sec	0 ... 240	Off-delay of output relay #2



Control Input #1 (Cont.)

Setting Range	Setting Range	Description
SPEED SWITCH OFF	On/Off	Speed switch/stop indicator (locked-rotor during start) On/Off Or / and auxiliary contact of motor contactor "motor switched on" for motors with I_m< 20 % I_e.
TRIP TIME OF OC		Trip delay chosen for overcurrent / locked rotor
TRIP ON OC RELAY		Trip on relay chosen for overcurrent/locked-rotor
DISABLE FUNCTION OFF	On/Off	Disable protective function On/Off
ASYMMETRY PROT NOT DISABLED	Not disabled/ disabled	Asymmetry protection Active/locked out
OVERCURRENT PROT NOT DISABLED	Not disabled/ disabled	Overcurrent/locked-rotor protection Active/locked out
EARTH FAULT PROT NOT DISABLED	Not disabled/ disabled	Earth-fault protection Active/locked out
SHORT CIRC PROT NOT DISABLED	Not disabled/ disabled	Short-circuit protection Active/locked out
UNDERLOAD PROT NOT DISABLED	Not disabled/ disabled	Underload protection Active/locked out
START INHIBIT NOT DISABLED	Not disabled/ disabled	Limiting starts/hour Active/locked out
PTC PROT NOT DISABLED	Not disabled/ disabled	PTC protection Active/locked out
PT100 PROT NOT DISABLED	Not disabled/ disabled	PT100 (RTD) protection Active/locked out

Control Input #2



LCD	Setting Range	Description
CONTROL INPUT #2 OFF	On/Off	Control input #2 On/Off
DELAY AUX REL #3 OFF	On/Off	Timer function of output relay #3 On/Off
ON DELAY AUX #3 1 sec	0 ... 240	On-delay of output relay #3
OFF DELAY AUX #3 2 sec	0 ... 240	Off-delay of output relay #3
NEW FLC OFF	On/Off	Setting 2nd rated motor current On/Off
PRIMARY C.T. #2 NO	No/Yes	Use of primary c.t. for 2nd rated motor current
PRIMARY C.T. RATIO 1	1 ... 2 000	Current ratio of primary c.t. eg. 800 A / 5 A, setting = 160
NEW FLC 20 A	0.50 ... 2 000	Setting 2nd rated motor current On/Off
DISABLE FUNCTION OFF	Not disabled/ disabled	Disable protective function On/Off
ASYMMETRY PROT NOT DISABLED	Not disabled/ disabled	Asymmetry protection Active/locked out
OVERCURRENT PROT NOT DISABLED	Not disabled/ disabled	Overcurrent/locked-rotor protection Active/locked out
EARTH FAULT PROT NOT DISABLED	Not disabled/ disabled	Earth-fault protection Active/locked out
SHORT CIRC PROT NOT DISABLED	Not disabled/ disabled	Short-circuit protection Active/locked out
UNDERLOAD PROT NOT DISABLED	Not disabled/ disabled	Underload protection Active/locked out
START INHIBIT NOT DISABLED	Not disabled/ disabled	Limiting starts/hour Active/locked out

PTC PROT NOT DISABLED	Not disabled/ disabled	PTC protection Active/locked out
PT100 PROT NOT DISABLED	Not disabled/ disabled	PT100 (RTD) protection Active/locked out

5.5.3 Bulletin 825-MLV Option Card

Phase Sequence Protection

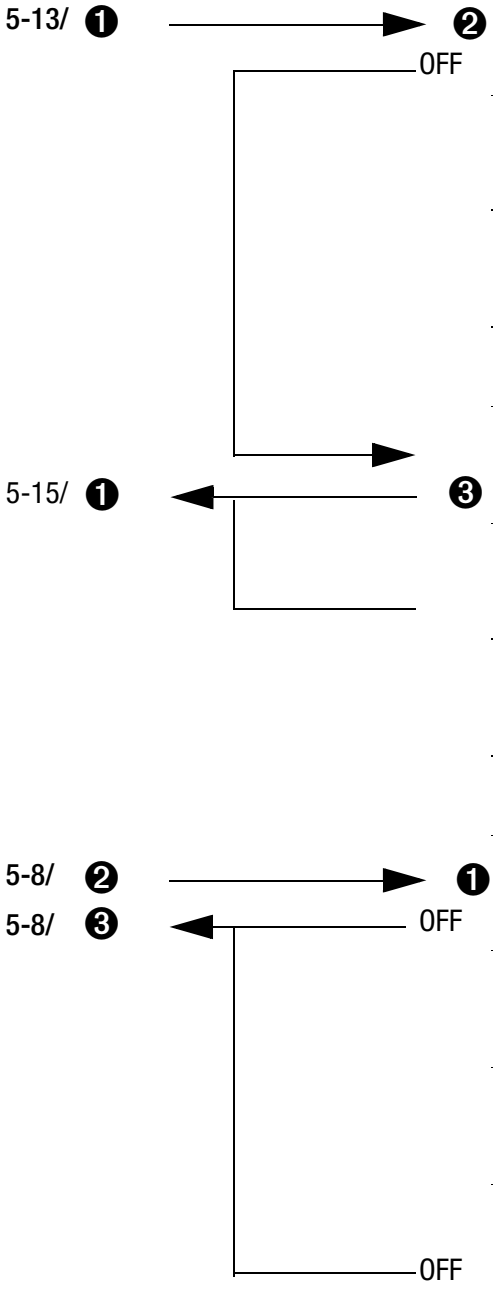
LCD	Setting Range	Description
PHASE-REVER TRIP OFF	On/Off	Phase sequence protection (based on motor supply voltage) On/Off
PHASE-REVER TRIP MAIN RELAY	All relays	Phase sequence protection Assignment of output relay

Phase Failure

LCD	Setting Range	Description
PHASE LOSS TRIP OFF	On/Off	Phase failure (based on motor supply voltage) On/Off
PHASE LOSS TRIP MAIN RELAY	All relays	Phase failure Assignment of output relay

Star-Delta (Wye-Delta) Starting

LCD	Setting Range	Description
STAR DELTA OFF	On/Off	Star-delta starting On/Off
STAR AUX REL #4	Relay#4	Star-delta starting Assignment of star output relay
DELTA AUX REL #5	Relay#5	Star-delta starting Assignment of delta output relay
SET STAR TIME OFF	On/Off	Star-delta starting Max. time on star on/off



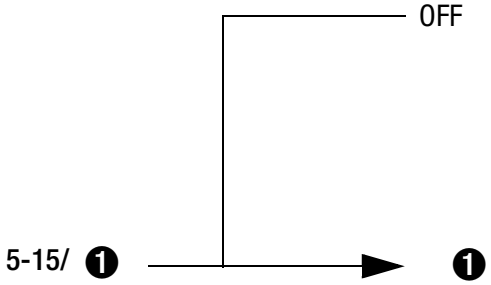
5-8 ❸ ◄ ❷	STAR TIME 10 sec	1 ... 240	Star-delta starting Max. time on star

5.5.4 Bulletin 825-MMV Option Card

Temperature Sensor PT100 (RTD)

	LCD	Setting Range	Description
5-14/ ❸ ► 5-17/ ❶ ◄ ❶	PT100 PROT OFF	On/Off	PT100 protection (stator/ bearings) On/Off
	PT100 #1 TRIP OFF	On/Off	PT100 #1 protection On/Off
	#1 TRIP TEMP 50 °C	50 ... 200	PT100 #1 Tripping temperature
	PT100 #2 TRIP OFF	On/Off	PT100 #2 protection On/Off
	#2 TRIP TEMP 50 °C	50 ... 200	PT100 #2 Tripping temperature
	PT100 #3 TRIP OFF	On/Off	PT100 #3 protection On/Off
	#3 TRIP TEMP 50 °C	50 ... 200	PT100 #3 Tripping temperature
	PT100 #4 TRIP OFF	On/Off	PT100 #4 protection On/Off
	#4 TRIP TEMP 50 °C	50 ... 200	PT100 #4 Tripping temperature
	PT100 #5 TRIP OFF	On/Off	PT100 #5 protection On/Off
	#5 TRIP TEMP 50 °C	50 ... 200	PT100 #5 Tripping temperature
	PT100 #6 TRIP OFF	On/Off	PT100 #6 protection On/Off

LCD	Setting Range	Description
#6 TRIP TEMP 50 °C	50 ... 200	PT100 #6 Tripping temperature
PT100 #1-6 TRIP MAIN RELAY	All relays ex 4, 5	PT100 #1. . .#6 Tripping
PT100 #1-6 RESET MANUAL	Manual/ auto	PT100 #1. . .#6, reset PT100 trip Manual/auto-matic
PT100 #1 WARNING OFF	On/Off	PT100 #1 warning On/Off
#1 WARNING TEMP 50 °C	50 ... 200	PT100 #1 Warning temperature
PT100 #2 WARNING OFF	On/Off	PT100 #2 warning On/Off
#2 WARNING TEMP 50 °C	50 ... 200	PT100 #2 Warning temperature
PT100 #3 WARNING OFF	On/Off	PT100 #3 warning On/Off
#3 WARNING TEMP 50 °C	50 ... 200	PT100 #3 Warning temperature
PT100 #4 WARNING OFF	On/Off	PT100 #4 warning On/Off
#4 WARNING TEMP 50 °C	50 ... 200	PT100 #4 Warning temperature
PT100 #5 WARNING OFF	On/Off	PT100 #5 warning On/Off
#5 WARNING TEMP 50 °C	50 ... 200	PT100 #5 Warning temperature
PT100 #6 WARNING OFF	On/Off	PT100 #6 warning On/Off
#6 WARNING TEMP 50 °C	50 ... 200	PT100 #6 Warning temperature



Temperature Sensor (Cont.)

LCD	Setting Range	Description
#1-6 WARNING ALARM RELAY	AL, #1 ... #6	PT100, #1. . .#6 warning Assignment of output relay
Tamb IN TH IMAGE OFF	On/Off	PT100 #7, allowance for ambient temperature in thermal simulation
INSULATION CLASS B	B, E, F	Insulation class of winding
OUTPUT 4...20 mA THERMAL	Thermal utiliz *I* Motor PT100 max.	Using the Analog Output for: Thermal utilization, Motor current, Max. PT100 temperature

5.5.5 Communication Board

LCD	Setting Range	Description
STATION NUMBER 02	 0 ... 63 0 ... 63 1 ... 247 1 ... 126	Bulletin 825-M* station number (DeviceNet) (R I/O) (MODBUS) (PROFIBUS)
BAUD RATE 04	 0 ... 2 0 ... 23 0 ... 182 0 ... 4	Baud-Rate (DeviceNet) (R I/O) (MODBUS) (PROFIBUS)

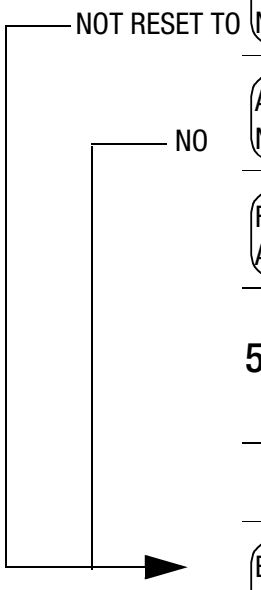
5.5.6 Relay Control

LCD	Setting Range	Description
REL #2-3 VIA COM NO	No / Yes	Control of relays #2 and #3 via communication allowed

5.5.7 Clear Recorded Values

LCD	Setting Range	Description
CLEAR REC VALUES NOT CLEAR	Not clear/ all clear	Clear/do not clear all recorded values

5.5.8 Reset Settings to Factory Settings (Default Values)



LCD	Setting Range	Description
FACTORY SETTINGS NOT RESET TO	Not reset to/ All reset to	Reset/Not reset to factory settings
ARE YOU SURE? NO	No/Yes	Reset/Not reset all parameters to factory settings
FACTORY SETTINGS ALL IS RESET TO	–	Confirmation that all parameters are reset to the factory settings

5.5.9 End of Setting Parameters

LCD	Setting Range	Description
END SET VALUE	–	End of setting operating parameters

6.1 Overview

This chapter contains the following sections:

Section	Page
Checking the Installation	**6-1**
Checking the Wiring	6-2
Checking the Installation with the Control Voltage On	**6-2**
Switching on the Control Voltage	6-2
Checking the Set Parameters	6-2
Motor Current	6-3
Locked Rotor or Starting Current	6-4
Locked Rotor Time	6-4
Programming, Set-up, and Operation	**6-6**
Starting	6-6
Operating Checking the Actual Values	6-6

Careful, correct commissioning of the CET 4 is an important prerequisite for reliable protection of the motor and economic operation of the installation. Follow the procedures in this section to ensure that programming and set-up are correct.

ATTENTION: Checking and commissioning must be carried out only by qualified personnel.

6.2 Checking the Installation

ATTENTION: Disconnect the main switch and isolate the control circuit.

- CWE 4 Current Converter
  -Verify that its current range lies within the full load or the service current
- Primary Current Transformer (if used)
  -The transformer rating must be greater or equal to the full load or the service current.
  -The current ratio must be ... A /1A or ... A / 5A for use with current converter CWE 4-2.5 or CWE 4-20, respectivly.

- Core balance transformer
  - Verify that the output current of the core balance transformer is 5 ... 500 mA for the alarm or trip signal.
- CET 4
  - Verify that the power supply voltage has been properly selected for the control circuit voltage.
  - Verify that the appropriate option cards have been installed.
  - Verify that the indication meter (if required) is connected.

6.2.1 Checking the Wiring

- Primary current transformer, core balance transformers
- CWE 4
- CET 4
- Link between CET 4 and CWE 4
- Inputs, outputs
- Supply
- Communication
- Contacts 95 through 98 are marked down according to “electrically held“ / “non fail safe“ connection required.

6.3 Checking the Installation with the Control Voltage On

6.3.1 Switching on the Control Voltage

After applying control voltage, the CET 4 is ready for operation in approximately 3 sec.

- LCD shows "ACTUAL VALUE"
- Main relay; contact 95/96 is closed

6.3.2 Checking the Set Parameters

Methods

- CET 4 in Set Values mode

Access the parameters (or print them out) and compare them with the set values in the list of settings. The main settings are:

- Rated or service current
- Locked-rotor or starting current
- Permissible locked-rotor time

These three settings must be made individually for each motor. See page 5-2, *Setting the Operational Parameters*, for procedure.

6.3.3 Motor Current

- Ensure that the CET 4 rated current in amperes is equal to the ampere rating on the nameplate of the motor.
- Set the CET 4 rated current based on the service current of the motor, if the installation or motor nameplate current is not known.

1. Set the motor current approximately 10 ... 20 % higher than the assumed service current.
2. With the installation running normally, read the motor current on the LCD.
3. Set the CET 4 to the service current reading.

Example

Set current:	FULL LOAD CURR 140 A
Measured motor current:	I MOTOR 85 % Ie
Service current = $\frac{\%\ (I_e) \times I_e}{100} = \frac{85 \times 140\ A}{100} = 119\ A$	
Setting to service current:	FULL LOAD CURR 119 A
The motor current is now:	I MOTOR 100 % Ie

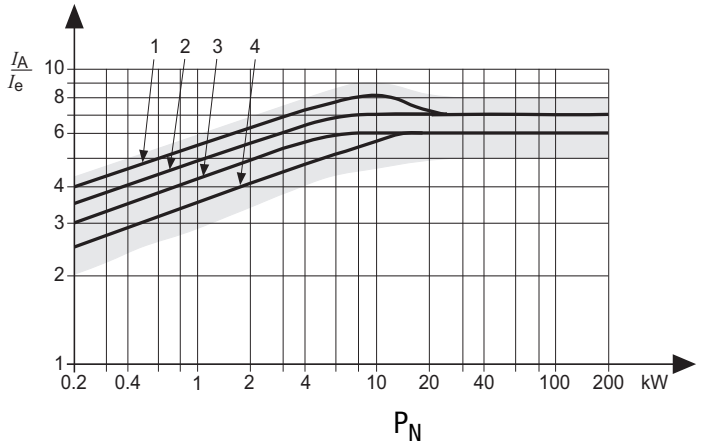
6.3.4 Locked Rotor or Starting Current

- Set the locked-rotor or starting current as the multiple of rated current $I_A : I_e$ according to specifications given by the manufacturer.
- If no specifications are available, the starting current can either be measured with the CET 4 or read from Figure 6.1
- The CET 4 factory-setting is 6 x I_e.

LCD:

```
LOCKED ROT CURR
6.00 x Ie
```

Figure 6.1 Range of Starting Currents of Standard Motors expressed as Multiple of the Rated Service Current



1 Approximate value for 2-pole motors , speed 3 000 rpm
2 Approximate value for 4-pole motors , speed 1 500 rpm
3 Approximate value for 6-pole motors , speed 1 000 rpm
4 Approximate value for 8-pole motors , speed 750 rpm
P_N Rated output power in service

6.3.5 Locked Rotor Time

- Normal setting of locked rotor time (i.e., when standard motors or permissible locked rotor time is known)
- The setting of the locked rotor time must be equal to or less than the value quoted by the manufacturer.
- The CET 4 factory setting is 10 sec. If no application details are available, and the starting conditions are not special, leave the setting at 10 sec.

LCD:

```
LOCKED ROT TIME
10 sec
```

- Setting locked rotor time to a minimum level.
  This procedure enables you to set the locked rotor time to a minimum, so that the motor and installation are better protected.

1. Choose a locked rotor time that is less than the probable starting time (e.g., 2 sec. for thermally rapid underwater motors).
2. Start the motor and allow it to cool down after a thermal trip.
3. Increase the locked-rotor time until starting succeeds reliably.

- Setting the locked rotor time when the motor starting time is known:

Example:

Known starting time of the motor is t_A = 15 sec.

Locked-rotor time to be set:

approximately $\frac{t_A}{1.4} = \frac{15}{1.4} = 11\,\text{sec}$

- Setting the locked rotor time with the aid of the indication of thermal utilization

  -CET 4 "ACTUAL VALUES"

LCD:

```
TH UTILIZ 00 %
```

-Set the locked rotor time so that the CET 4 does not trip (< 100%) with the least favorable service load, e.g., at the end of a heavy start. Note that for this procedure, the motor must be of adequate size for the intended application.

6.4 Programming, Set-up, and Operation

During programming, set-up, and operation, the actual operational values can be continuously monitored. To do this, switch the display to "Actual Values" (see Chapter 3).

6.4.1 Starting

LCD	Operation	Description
I MOTOR 00 % Ie	Motor start	The motor current, depending on the type of motor, must drop from about 400 ... 800 % I_e to the service current of 100 % I_e.

6.4.2 Operating

Checking the Actual Values

LCD	Setting Range	Description
ACTUAL VALUES		Indication of actual values
I MOTOR ... A	0.00 … 49.99 50 … 24 000	Motor current in ... A
TH UTILIZ ... %	0 … 100	Thermal utilization
I MOTOR ... % Ie	0 / 20 … 999	Motor current as a percentage of rated service current (I_e)
I 1 ... % Ie	0 / 20 … 1 200	Motor current I 1 (phase L1), percentage of rated service current (I_e)
I 2... % Ie	0 / 20 … 1 200	Motor current I 2 (phase L2), percentage of rated service current (I_e)
I 3... % Ie	0 / 20 … 1 200	Motor current I 3 (phase L3), percentage of rated service current (I_e)
TRIP IN ... sec	1 … 9999	CET 4 will trip in . . . sec.

Checking the Actual Values (cont.)

LCD	Setting Range	Description
RESET IN ... sec	1 … 9999	CET 4 can be reset in . . . sec
ASYM ... %	1 … 100	Current asymmetry in percent
I earth-H ... % I	1 … 100	Earth (ground) fault current (Holmgreen = Residual) as percentage of actual service current(I)
I earth-C ... mA	5 … 1 000 mA 1.00 … 50.00 A	Earth (ground) fault current in mA / A with core balance transformer
Tambient ... °C	0 … 210	Ambient temperature in °C (PT100, #7)
PT100 #1 ... °C	0 … 210	Temperature in °C (PT100, #1)
PT100 #2 ... °C	0 … 210	Temperature in °C (PT100, #2)
PT100 #3 ... °C	0 … 210	Temperature in °C (PT100, #3)
PT100 #4 ... °C	0 … 210	Temperature in °C (PT100, #4)
PT100 #5 ... °C	0 … 210	Temperature in °C (PT100, #5)
PT100 #6 ... °C	0 … 210	Temperature in °C (PT100, #6)
DevNet	DevNet R I/O MODBUS PROFIBUS	Display of communication option DeviceNet 825-MDN Remote I/O 3600-RIO Modbus 3600-MBS PROFIBUS CPB 4
END ACT VALUE	–	End of actual values

7.1 Overview

This chapter contains the following sections:

Section	Page
General	7-1
Checking without Test Equipment	7-1
Functional Check with the <Test> Button	7-1
Indication of Recorded Values	7-1
List of Recorded Values	7-2
Checking with Test Equipment	7-5
CET 4 Test Unit	7-5
Test with Three-phase Current Source	7-5
Test with Single-phase Current Source	7-6

7.2 General

The correct functioning of the CET 4 can be checked by several methods, depending on the requirements:

- With the <Test> button
- With the test condition set
- With a single- or three-phase current source

A test may be beneficial:

- during commissioning
- following an interruption in operation
- following overhauls
- following reconstruction of the installation

After a test is conducted, the display provides information on the running time of the CET 4 and the motor, the number of operations performed by the motor, the contactor, etc. From this information, necessary maintenances and replacements in the installation can be derived.

7.3 Checking without Test Equipment

7.3.1 Functional Check with the <Test> Button

With the motor at standstill, the functions of the thermal protection, all alarms, trips, and tripping times can be checked with the aid of the <Test> button. See page 3-10 for the specific procedures.

7.3.2 Indication of Recorded Values

All important statistical data can be read on the LCD of the CET 4. See page 3-9 for procedure.

From the recorded values, data can be used to determine:

- Running time of the motor, the CET 4, contactor, etc.
- Necessary service jobs
- Operational behavior of motor and installation
- Causes shortly before tripping and the moment of tripping
- Misuse information, such as too many emergency starts, etc.

The table below lists the recorded values accessible from the CET 4.

List of Recorded Values

LCD	Description
RECORDED VALUES	Mode: Recorded values
CET 4 MAIN TIME --- h -- min	Total CET 4 running time (incl. interruption of control voltage) in hours, minutes
MOT RUNNING TIME --- h -- min	Total motor running time in hours, minutes
SINCE LAST START --- h -- min	Time since last start in hours, minutes
SINCE 1PRV START --- h -- min	Time since one start prior to last start in hours, minutes
SINCE 2 PRV START --- h -- min	Time since two starts prior to last start in hours, minutes
SINCE 3 PRV START --- h -- min	Time since three starts prior to last start in hours, minutes
SINCE 4 PRV START --- h -- min	Time since four starts prior to last start in hours, minutes
SINCE LAST TRIP --- h -- min	Time since last trip in hours, minutes

List of Recorded Values (cont.)

LCD	Description
SINCE 1 PRV TRIP --- h -- min	Time since one trip prior to last trip in hours, minutes
SINCE 2 PRV TRIP --- h -- min	Time since two trips prior to last trip in hours, minutes
SINCE 3 PRV TRIP --- h -- min	Time since three trips prior to last trip in hours, minutes
SINCE 4 PRV TRIP --- h -- min	Time since four trips prior to last trip in hours, minutes
CAUSE LAST TRIP ASYMMETRY TRIP	Cause of last trip, e.g., asymmetry
CAUSE 1 PRV TRIP ASYMMETRY TRIP	Cause of one trip prior to last trip, e.g., asymmetry
CAUSE 2 PRV TRIP OVERCURRENT TRIP	Cause of two trips prior to last trip, e.g., overcurrent
CAUSE 3 PRV TRIP THERMAL TRIP	Cause of three trips prior to last trip, e.g., thermal
CAUSE 4 PRV TRIP PTC TRIP	Cause of four trips prior to last trip, e.g., thermistor
SINCE EMG START --- h -- min	Time elapsed since last emergency start in hours, minutes
SINCE POWER OFF --- h -- min	Time elapsed since last power failure in hours, minutes
DURATION POW OFF --- h -- min	Duration of power failure in hours, minutes
I BEF LAST TRIP --- % Ie	Motor current before last trip as a percentage of rated service current (I_e)
AS BEF LAST TRIP --- %	Asymmetry before last trip in percent
EF BEF LAST TRIP --- % I	Earth (ground) fault current before last trip as percentage of rated current or . . . mA

List of Recorded Values (cont.)

LCD	Description
MAX T BEF L TRIP --- °C	Maximum temperature before last trip in °C (PT100, #1 ... #6)
TH BEF LAST TRIP --- %	Thermal capacity used before last trip 100 % = thermal trip
NUMBER START ---	Total number of motor starts
NUMBER TH TRIP ---	Total number of trips, thermal
NUMBER AS TRIP ---	Total number of trips, asymmetry
NUMBER OC TRIP ---	Total trips overcurrent/locked rotor
NUMBER EF TRIP ---	Total trips, earth (ground) fault
NUMBER SC TRIP ---	Total trips, short-circuit
NUMBER UL TRIP ---	Total trips, underload
NUMBER PTC TRIP ---	Total trips, overtemperature (PTC)
NUMBER PR TRIP ---	Total trips, phase sequence (motor supply)
NUMBER PL TRIP ---	Total trips, phase failure motor supply)
NUMB PT100 TRIP ---	Total trips, overtemperature (PT100)
TO CLEAR REC VAL GOTO END SET VAL	To clear all recorded values (except running time or motor and CET 4) go to end set values
END REC VALUES	End of recorded values

7.4 Checking with Test Equipment

A complete check of the CET 4 components can be performed with the CET 4 test unit and a three-phase current source.

7.4.1 CET 4 Test Unit

With the test unit, all protective functions set on the CET 4 Motor Protection System can be checked, including the pickup levels and tripping delays.

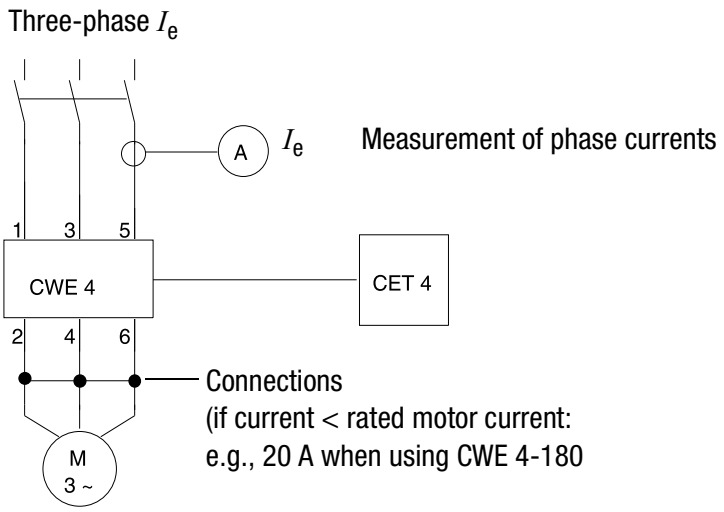
Test with Three-phase Current Source

ATTENTION: This test should be performed only by qualified personnel.

Using a three-phase current source, the main circuit, any primary current transformer, and the current detection module, CWE 4 can be tested.

Because the functions of the CET 4 have already been checked with the test unit, it is sufficient to supply a current of 1 x I_e. As an alternative, you can measure the three phase currents exactly and compare the readings with the values indicated by the LCD on the CET 4.

Figure 7.1 Test with a Three-phase Current Source

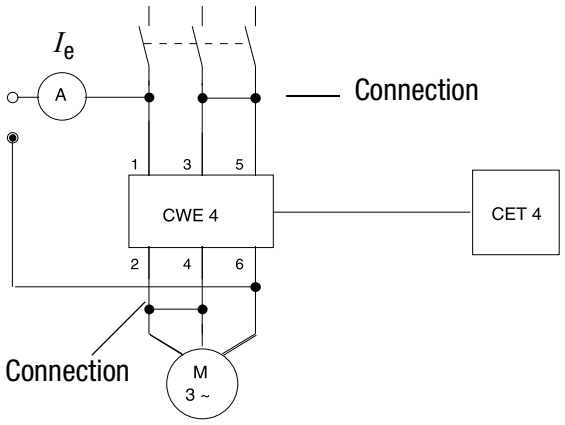


Test with Single-phase Current Source

ATTENTION: This test should be performed only by qualified personnel.

The test with a three-phase current source described on page 7-5 can also be performed with a single-phase source. To do this, the earth (ground) fault protection by the Holmgreen method must be switched off.

Figure 7.2 Test with a Single-phase Current Source



Note: The test current may not flow through the core balance transformer.

Chapter 8 Error Diagnosis and Troubleshooting

8.1 Overview

This chapter contains the following sections:

Section	Page
Alarm, Warning	**8-1**
Procedure when Alarm/Warning Picks Up	8-2
Trip	8-3
Fault Codes	**8-4**
Possible Causes and Actions	8-4
Procedure if "Warning" does not reset	8-9
How to get rid of Warning?	8-10
Procedure if "TRIP" can not be reset	8-10
a). Thermal Trip	8-10
Indication	8-10
b). Other Trips	8-10
Indication	8-10
Cause for this Condition	8-11
How to Reset ?	8-11

8.2 Alarm, Warning

If an impending defect is detected early enough, motor damage can be minimized.

- Lower repair costs
- Less downtime (increased productivity)

Alarm thresholds can be set for:

- Thermal utilization of the motor
- Overcurrent
- Asymmetry
- Underload
- Earth (ground) fault with core balance transformer
- Stator and bearing temperature with PT100

When the alarm threshold is reached, the LED flashes, the LCD indicates the type of alarm, and the selected output relay picks up.

8.2.1 Procedure when Alarm/Warning Picks Up

Example: Asymmetry

When an asymmetry condition occurs and the related threshold is reached, the following responses occur:

- LED flashes
- LCD:

  AS WARNING

- The assigned output relay picks up
- Cause of the warning may be:
  - Unbalanced mains
  - Defective motor winding
  - Defective contacts

Actions

If the installation can be shut down without loss of production or without affecting safety:

- Switch off the installation
- Search for the fault and repair it

If it is important to keep the operation running:

- Continuously monitor the level of "ACTUAL VALUES" ASYM ... %
- If the warning level continues to rise, measures should be taken so that the installation can be shut down soon.
- If the alarm level remains steady in the region of the set warning threshold, it is permissible to wait with fault location and repair until the next planned interruption in operation.

ATTENTION: While the warning is on (red LED flashing), switching off the warning function is not allowed. (see page 8-9)

8.2.2 Trip

Example: Asymmetry

Faults in the motor or the installation can develop and lead to the set threshold being rapidly exceeded. When this occurs and the related threshold is reached, the following responses occur:

- LED lights
- LCD:

ASYMMETRY TRIP

- The assigned output relay picks up

Actions

Determine the trip cause and correct the problem before re-starting the motor installation.

ATTENTION: While the trip is on (red LED on), switching off the protection function is not allowed. (see page 8-10)

8.3 Fault Codes

8.3.1 Possible Causes and Actions

LCD	Designation	Possible Causes	Actions
	No indication	• No supply voltage • Wrong supply module in CET 4 • CET 4 defective • Thermal trip of supply module Supply voltage too high - Ambient temp. too high - Current consumption too high - Supply module failed	• Ensure power supply is on • Check the supply • Insert correct supply module. If the voltage applied to the supply module was too high, it and the functions of the CET 4 must be tested. • If no fault is found or if in doubt, send the CET 4 back to the factory for repair. • Switch off control supply. Restore normal conditions and let the CET 4 cool down for approx. 30 min. • Send the CET 4 back to the factory for repair.
	From V2.17 and later: No indication, red LED on	• Watch Dog Microprocessor-failure	• Send the CET 4 back to the factory for repair
DEFECT #1	Real time clock fault	• RTC defective	• Send the CET 4 back to the factory for repair
DEFECT #2	µP fault (RAM)	• Microprocessor RAM defective	• Send the CET 4 back to the factory for repair
CWE 4 NOT CON	Open circuit CET 4 to CWE 4	• Cable CET 4 to CWE 4 not connected or broken	• Check connections • Test cable (open/short-circuit) - Replace cable if necessary
CWE 4 ERROR	CWE 4 cannot be correctly recognized	• Link between CET 4 and CWE 4 defective • Fault in CET 4	• Check link between CET 4 and CWE 4 and replace if necessary • Switch supply off and on again • If the fault cannot be remedied, send the CET 4 back to the factory for repair.
Ie OUT OF RANGE	Rated current and setting do not agree	• Rated current CWE 4 does not agree with CET 4 setting • Wrong CWE 4 • Wrong setting	• Check setting "FULL LOAD CURR" and CWE 4 • Install a correct CWE 4 • Press " Values" until " SET Values" on LCD, correct "FULL LOAD CURR" (within about 5 sec.)

ERROR ACT VALUES	Error in actual values	• Data could not be saved when supply last interrupted	• Press Reset • Check supply • If the fault repeatedly occurs, send the CET 4 back to the factory for repair.
ERROR REC VALUES		• Hardware fault	• Send the CET 4 back to the factory for repair.
THERMAL WARNING THERMAL TRIP	Thermal warning Thermal trip	• Overloaded • Transported material jammed • Mechanical damage, bearings, etc. • Settings of rated current or tripping time too low • Interrupted start: motor inadequately cooled • More than one warm start/ hour • Ambient temperature too high (Function PT100, #7 ON) • Very high third harmonic • Cooling constant ratio has been changed	• Reduce load • Switch off installation, remedy trouble • Repair the damage. • Raise "FULL LOAD CURR"/ "LOCKED ROT TIME" to permissible motor values • Wait until motor has cooled down • (LCD: TH UTIL . .% appr. 20 %) • If permissible, increase number of warm starts/h • If possible, reduce load • Raise I_e setting accordingly • Check and reset to correct setting (factory setting 2.5)
ERROR SET VALUES		• Setting of locked rotor current and/or locked rotor time are outside the permissible range	• Press "Values" until "SET VALUES" on LCD • Set "LOCKED ROT CURR" to 6 x I_e • Set "LOCKED ROT TIME" to 10 sec. • Set "LOCKED ROT CURR" and "LOCKED ROT TIME" correctly within permissible range (see chap. 3)

(cont.)

LCD	Designation	Possible Causes	Actions
AS WARNING ASYMMETRY TRIP	Asymmetry warning Asymmetry trip	• Mains unbalanced	• If asymmetry inadmissibly high, clarify cause with electric company. • If asymmetry has values usual for the area, raise threshold in the CET 4.
		• Blown fuse - Short-circuit/Earth (ground) fault - Failure during starting	- Repair the trouble, replace the fuse - Redimension fuse (note short-circuit coordination)
		• Motors idling (e.g., pumps)	• Raise threshold in CET 4 to permissible level
		• Poor contacts (terminals, contactor, breaker, etc.)	• Repair trouble.
		• Phase lead broken (motor lead, link between CET 4 and CWE 4)	• Replace or repair cable
		• Asymmetrical motor winding	• If asymmetry is acceptable, raise threshold in CET 4; otherwise repair motor.
		• Main current transformer error - Metering class current transformer instead of protection current transformer - Wrong current range - Current transformer rating too low - Incorrect CT wiring	- Insert the correct current transformer. - Replace the current transformer. - Replace the current transformer. - Check and correct wiring.
OC WARNING OVERCURRENT TRIP	Overcurrent warning Overcurrent trip	• Overload	• Reduce load or raise pickup threshold.
		• Transported material jammed	• Switch off installation, remedy cause.
		• Pickup threshold set too low	• Raise pickup threshold.
		• Mechanical damage to bearings and transmission system	• Repair the damage.
		• Stalling during start (causes as for stallingjamming	• Switch off installation, remedy cause.
EF HOLMG TRIP	Earth (ground) fault (Holmgreen/ Residual) trip	• Earth (ground) fault motor winding or cable	• Repair damage.
		• Trip when running: - Primary current transformer wrongly wired	- Correct wiring
		- Primary current transformer saturated	- Raise pickup threshold
		- High proportion of third harmonic in star-delta	- Raise pickup threshold to 50 % or more

EF C WARNING	Earth (ground) fault warning with core balance transformer	• Trip during start: Primary and core balance transformer wrongly wired • Long motor cable	• Correct the wiring, (core balance transformer may only surround the three motor leads) • Raise pickup threshold.
EF CORE TRIP	Earth (ground) fault trip with core balance transformer	• Earth (ground) fault in motor winding or cable due to: - Moisture - Dirt - Mechanical damage	• Eliminate cause.
SHORT CIRC PROT	Short-circuit trip	• Short-circuit or earth (ground) fault in motor winding or cable • Trip when motor is switched on, due to inrush current • Pickup threshold is $< I_A$	• Repair damage. • Increase trip delay to > 0.1 s. • Set pickup threshold to $> I_A$.
UL WARNING	Underload warning	• Underwater pump running dry • Faulty fan blades	• Eliminate cause, lower pickup threshold if necessary or increase trip delay. • If tripping takes place too soon after starting, increase the start delay.
UNDERLOAD TRIP	Underload trip	• Torn conveyor belt • Broken transmission elements • Pumping against a closed valve • • Current setting I_e too high	• Set correct value.
START INHIB TRIP	Max. number of starts/h reached	• Maximum number of starts has been exceeded.	• Wait until a further start is permissible. Release will be automatic. • If a further start is permissible, increase number of start/hour by "1" and start again.
START CONT TRIP	Start in max. starting time not possible	• Overloaded • Transport material jammed • Viscous material	• Reduce load or raise max. starting time to permissible value. • Eliminate cause. • Raise max. starting time to permissible value.

(Cont.)

LCD	Designation	Possible Causes	Actions
PTC TRIP	PTC trip	• PTC or PTC leads short-circuited or broken • Stator winding overheated by: - Overload - Too many starts/hour - Too many warm starts/hour - Obstructed cooling - High ambient temperature	• Check leads, remove fault. PTC: Motor for repair. If not possible at , switch off PTC monitoring "PTC PROT/OFF" • Wait until motor has cooled down sufficiently for a reset. - Search for cause and eliminate. - Reduce starts/hour. - Reduce number of warm starts/hour. - Clean motor and cooling air intake. - Protect against heat; reduce load or switch off installation.
PHASE REVER TRIP	Phase sequence protection (motor supply)	• Wrong phase sequence of supply to CWE 4	• Connect phase leads in correct sequence.
PHASE LOSS TRIP	Phase failure trip (based on motor supply)	• Faulty fuse: Short-circuit/earth (ground) fault • Failure during start • Broken lead	• Remedy damage, replace the fuse. • Redimension fuse (noting short-circuit coordination). • Check cables and terminal connections.
PT100 # ... WARNING PT100 # ... TRIP	PT100 #1. . . #6 (RTD) temperature warning PT100 #1. . . #6 (RTD) temperature trip	• Stator winding overheated due to overloading - Overload - Too many starts/hour - Too many warm starts/hour - Obstructed cooling - High ambient temperature	• Wait until motor has cooled down sufficiently to permit reset. - Search for cause and remedy. - Reduce start/hour - Reduce warm starts/hour - Clean motor and cooling air intake. - Protect against heat. Reduce load or shut down the installation, and wait until motor has cooled down sufficiently for a restart.

PT100 SHORT CIRC PT100 NO CONNECT	PT100 (RTD) has been short or open circuited. This message may appear together with a PT100 #1 (RTD) . . .TRIP	• Failure in PT100 (RTD) circuit	• Check cables, terminal connection and PT100 (RTD) sensor

8.3.2 Procedure if "WARNING" does not reset

Indication

- LCD
  Does not display the type of the Warning (LCD active)
- Red LED
  Flashing

Cause for this Condition

If the affected alarm function is switched "OFF" before the alarm has disappeared or the motor has been switched off, then the alarm stays on whether the motor is switched on or off.

How to get rid of Warning ?

- Go to "SET VALUES" mode.
- Switch on all Alarm Functions
  e.g. "THERMAL WARNING" "ON".
- As soon as the affected Warning Function is switched on again, then the Warning condition will disappear.
- Switch Warning Function off, if not required

8.3.3 Procedure if "TRIP" can not be reset

There are two reasons why a trip can not be reset if the motor is not running.

a). Thermal Trip

Indication

- LCD
  "THERMAL TRIP"
- Red LED
  On

How to Reset ?

The motor must have cooled down to the pre-set level, before the reset is possible:

"TH RESET LEVEL" Setting Range 10 ... 100 %
Factory Setting 50 %.

b). Other Trips

Indication

- LCD
  Does not display the type of the trip (LCD active)
- Red LED
  ON

Cause for this Condition

If the tripped protection function has been switched "OFF", before the trip has been reset, then the trip can not be reset the normal way.

How to Reset ?

- Go to "RECORDED VALUES" mode
- Go to "CAUSE LAST TRIP"
  e.g.. "ASYMMETRY TRIP"
- Go to "SET VALUES" mode
- Go to tripped Protection Function
  e.g. "ASYMMETRY TRIP"
- Switch Protection Function on
  e.g. "ASYMMETRY TRIP" "ON"
- Reset Trip
  Red LED goes off
- Switch Protection Function off, if not required

9.1 Overview

This chapter contains the following sections:

Section	Page
CET 4 Electronic Control and Protection System with Contactors	9-2
Main Circuit	9-2
Control Circuit	9-2
Star-Delta Starter with CET 4	9-3
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Control Circuit	9-3
Short-circuit Protection of Medium / High-voltage Motors	9-4
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Motors with Low Ideling Current (< 20 % I_e)	9-9
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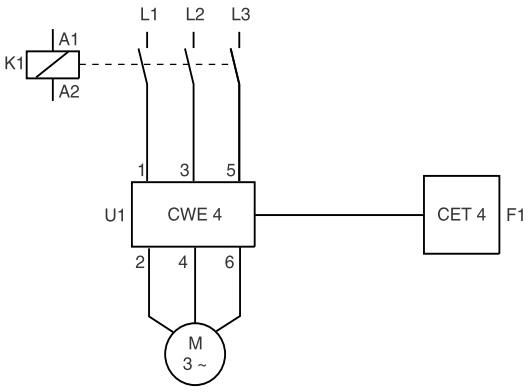
Time / Current Characteristic of CET 4	9-10

ATTENTION: Strictly observe the intallation instructions and the technical data for the contactors, auxiliary relays etc.

9.2 CET 4 Electronic Control and Protection System with Contactors

9.2.1 Main Circuit

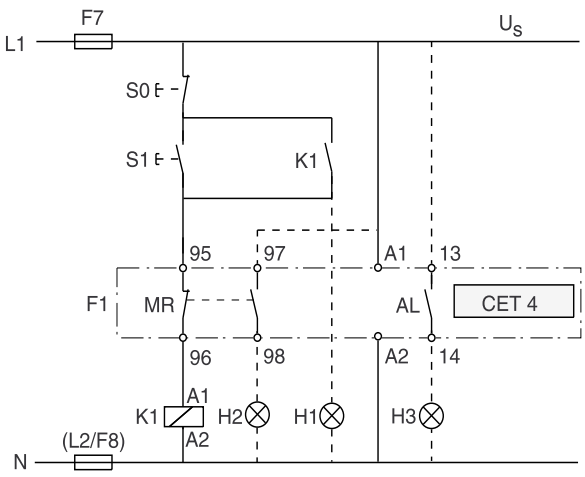
Figure 9.1 CET 4 and CWE 4



Converter module U1
CWE 4-2.5
CWE 4-20
CWE 4-180
CWE 4-630
CWE 4-630N

9.2.2 Control Circuit

Figure 9.2 Control by Momentary Contact



K1	Contactor
F1	Electronic control and protection system CET 4
S1	On push button
S0	Off push button
U_s	Control voltage
H1	Indicator "Contactor closed“
H2	Indicator "CET 4 tripped“
MR	Main output relay
AL	Alarm relay
H3	Indicator "Alarm/Warning“

ATTENTION: The mounting / wiring directions ar well ar the technical data of the used contactor must be considered.

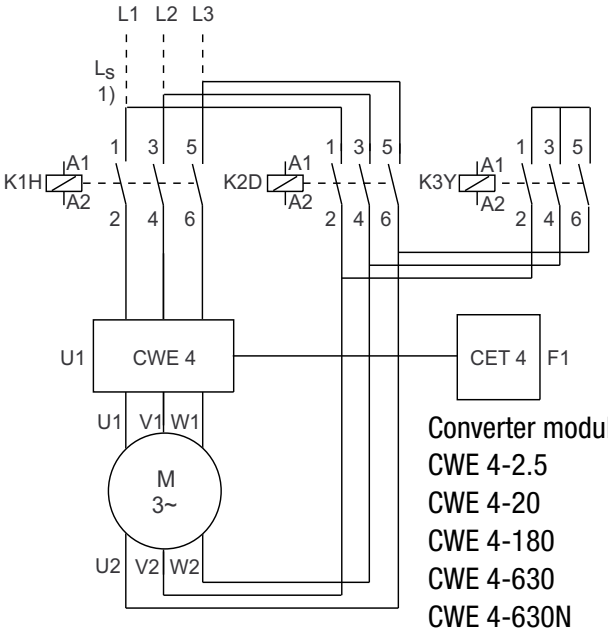
9.3 Star-Delta Starter with CET 4

9.3.1 Main Circuit

Figure 9.3 CET 4 and CWE 4

CET 4 settings:

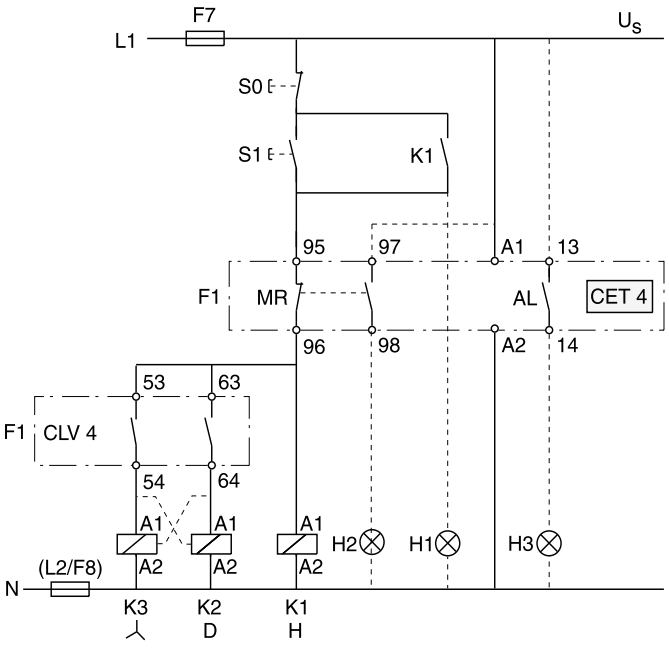
FULL LOAD CURR	FLC x 0.5774 [A]
LOCKED ROT CURR	$I_{BL\Delta}$ (... x I_e)
LOCKED ROT TIME	$t_{BL\Delta}$ (... sec.)
START TIME	> t_{startY} (... sec.)



Converter module U1
CWE 4-2.5
CWE 4-20
CWE 4-180
CWE 4-630
CWE 4-630N

9.3.2 Control Circuit

Figure 9.4 Control by Momentary Contact



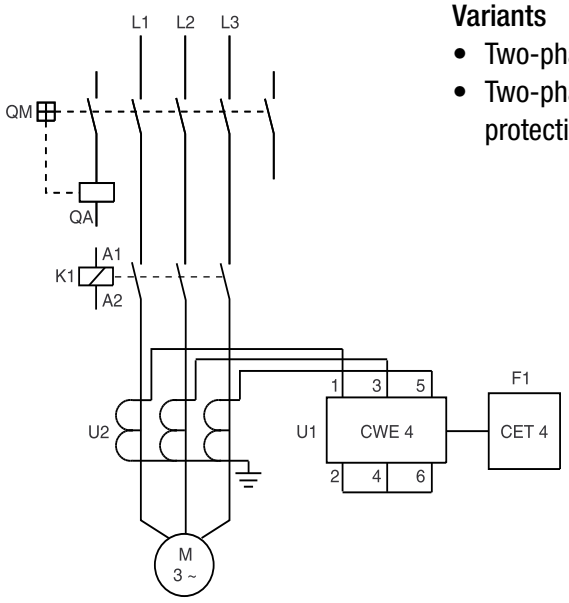
K1	Contactor
F1	Electronic control and protection system CET 4 with option CLV 4
S1	On push button
S0	Off push button
U_s	Control voltage
H1	Indicator “Contactor closed“
H2	Indicator “CET 4 tripped“
MR	Main output relay
AL	Alarm relay
H3	Indicator “Alarm/Warning“

9.4 Short-circuit Protection of Medium / High-voltage Motors

9.4.1 Main Circuit (with optional CST 4)

Three-phase Current Evaluation

Figure 9.5 CET 4 for Short-circuit Protection



Variants

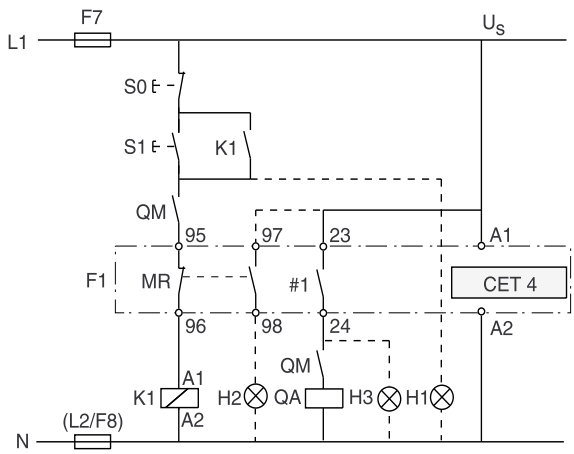
- Two-phase current evaluation
- Two-phase current evaluation and earth (ground) fault protection with core balance transformer

Converter module U1
CWE 4-2.5
CWE 4-20

Main current transformer U2
... A/5 A or ... A/1 A
For choice see Chapter 2

9.4.2 Control Circuit

Figure 9.6 Control by Momentary Contact



QM	Circuit-breaker
QA	Shunt trip coil
K1	Contactor
F1	Electronic control and protection system CET 4
S1	On push button
S0	Off push button
U_S	Control voltage
H1	Indicator "Contactor closed“
H2	Indicator "CET 4 tripped“ (except for short-circuit protection
MR	Main output relay
AL	Alarm relay
H3	Indicator "Alarm/Warning“
#1	Aux. relay, short-circuit indication

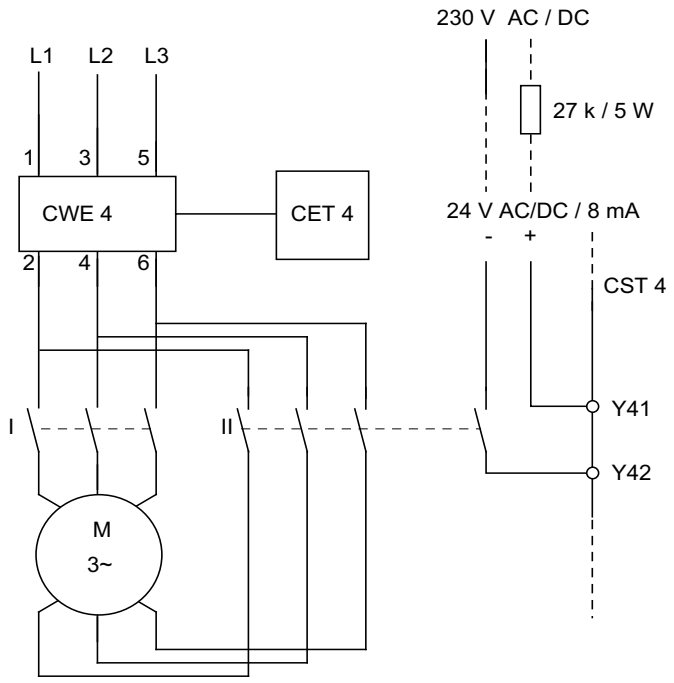
9.5 Two-speed Motors

The following ranges are possible for speeds I and II:

Speed I-II		Converter Module
0.5 ... 2.5 A	with	CWE 4-2.5
2.5 ... 20 A	with	CWE 4-20
20 ... 180 A	with	CWE 4-180
160 ... 630 A	with	CWE 4-630 or CWE 4-630N

9.5.1 Main Circuit

Figure 9.7

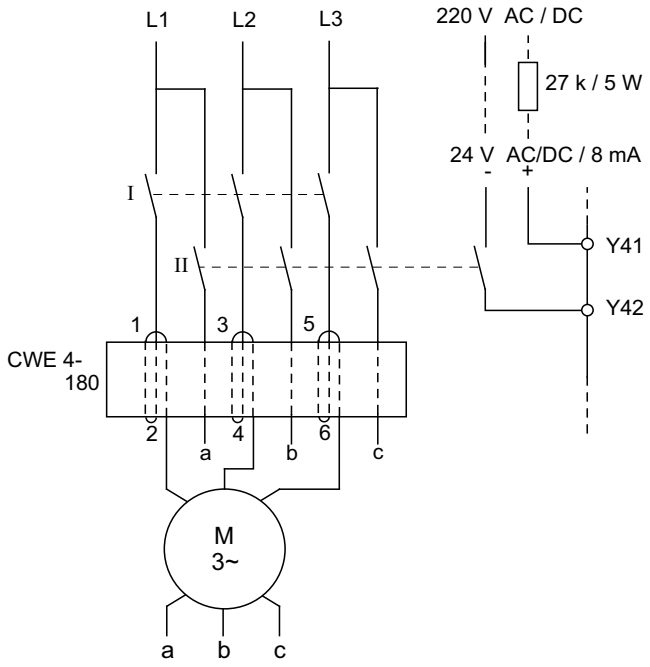


For setting the second current (speed II), see Chapter 5, "Control Input #2"

9.6 Two-speed Motor: Speed I < 20 A, Speed II > 20 A

9.6.1 Main Circuit

Figure 9.8



Speed I < 20 A
Motor supply cables loop n-times through CWE 4-180 until n x $I_e \geq 20$ A
Current setting CET 4: n x I_e (I)

Speed II > 20 A
Motor supply cables loop once through CWE 4-180
Current setting CET 4: I_e (II)

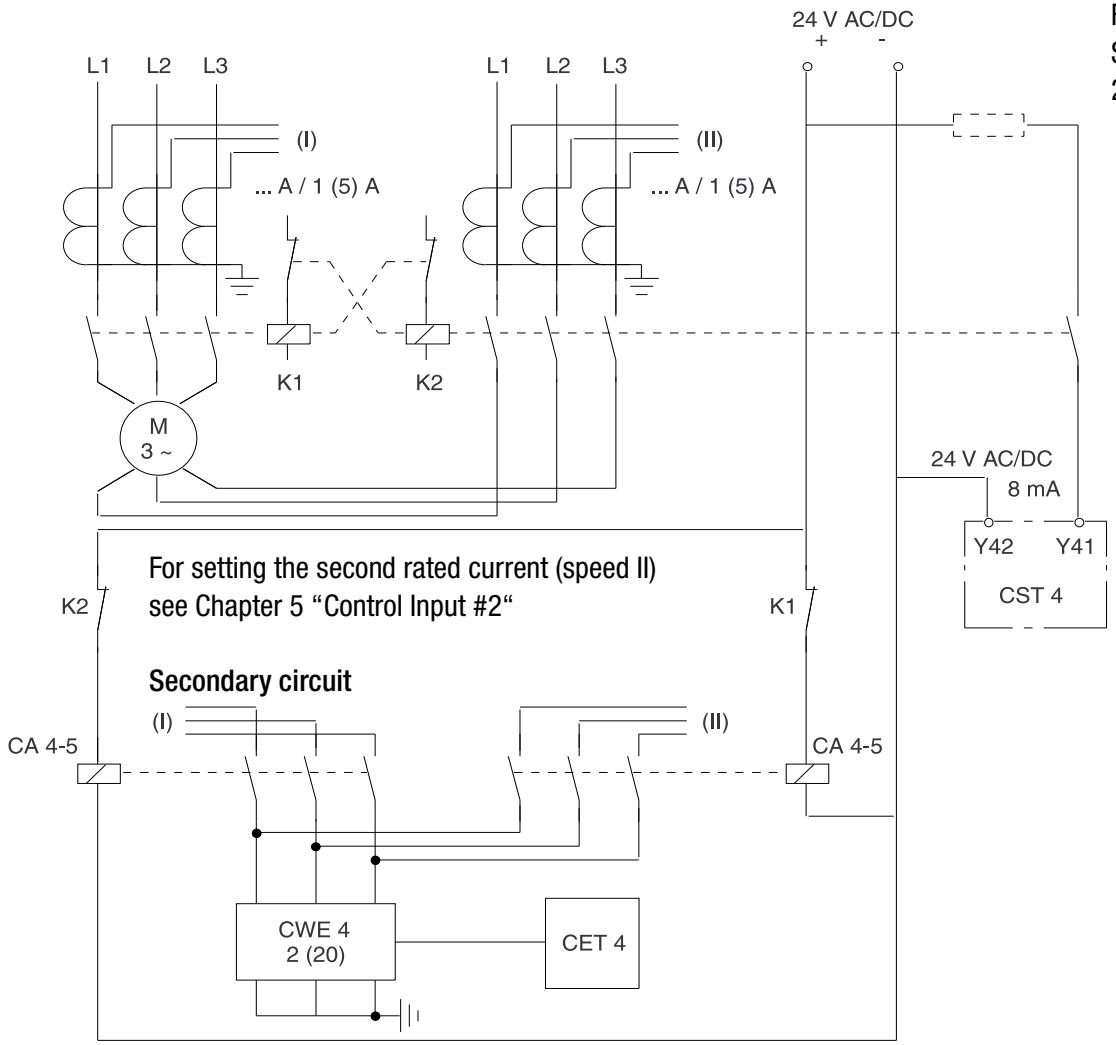
For setting the second rated current (speed II), see Chapter 5, “Control Input #2“.

9.7 Two-speed Motors with Primary Current Transformer

When a primary current transformer is used, two-speed motors of any rating can be protected.

9.7.1 Primary Circuit

Figure 9.9



9.8 Separately Ventilated Motors

Separately ventilated motors, which are also cooled when stationary, behave thermally as when running. Consequently, the cooling ratio must be set to "1."
LCD:

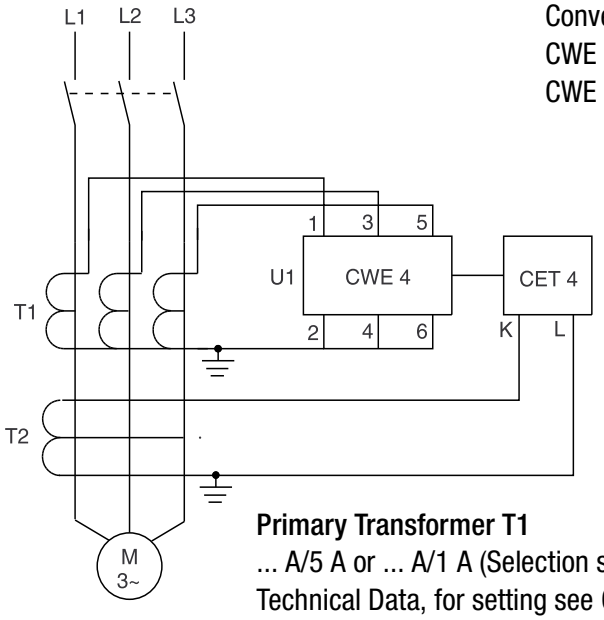
```
COOL-CONST RATIO
1.00
```

For setting the cooling ratio, see Chapter 5.

9.9 CET 4 and CWE 4 with Primary Transformer and Core Balance Transformer

9.9.1 Main Circuit

Figure 9.10



Converter module
CWE 4-2.5
CWE 4-20

Primary Transformer T1
... A/5 A or ... A/1 A (Selection see Chapter 2, Technical Data, for setting see Chapter 5)

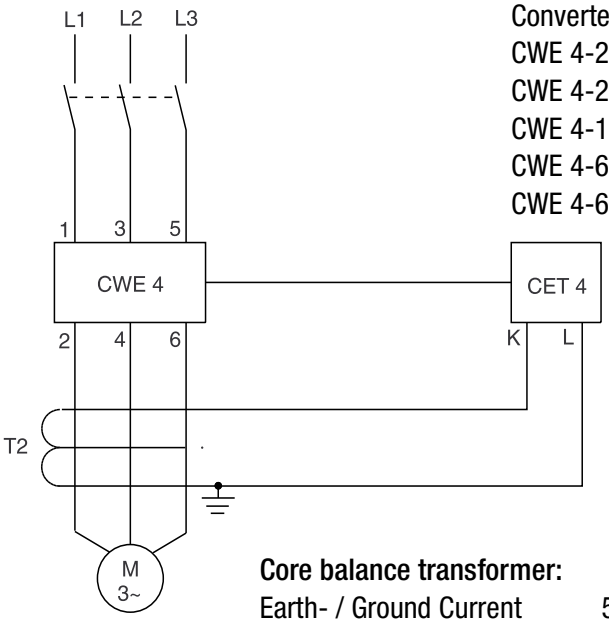
Core balance transformer T2:

Earth- / Ground Current	5 mA ... 60 A
Current ratio of core bal. c.t.	1 ... 2 000:1
Output from core bal. c.t.	0 ... 500 mA

9.10 CET 4 and CWE 4 with Core Balance Transformer

9.10.1 Main Circuit

Figure 9.11



Converter module
CWE 4-2.5
CWE 4-20
CWE 4-180
CWE 4-630
CWE 4-630N

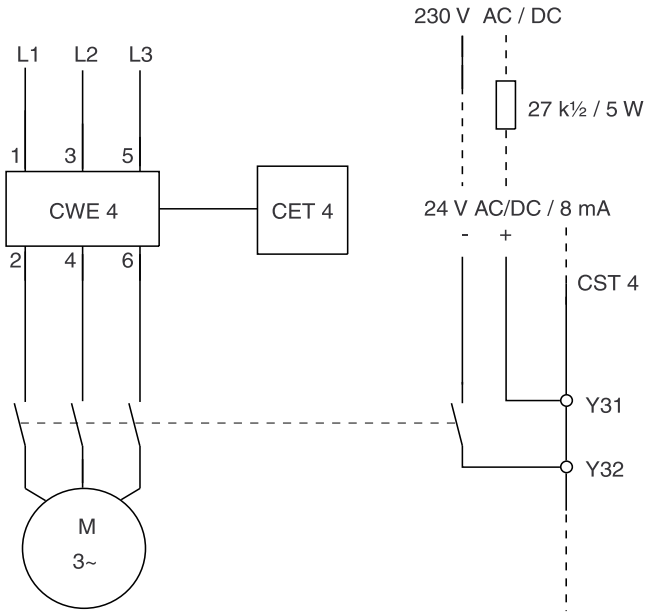
Core balance transformer:

Earth- / Ground Current	5 mA ... 50 A
Current ratio of core bal. c.t.	1 ... 2 000:1
Output from core bal. c.t.	0 ... 500 mA

9.11 Motors with Low Ideling Current (< 20 % I_e)

9.11.1 Main Circuit

Figure 9.12

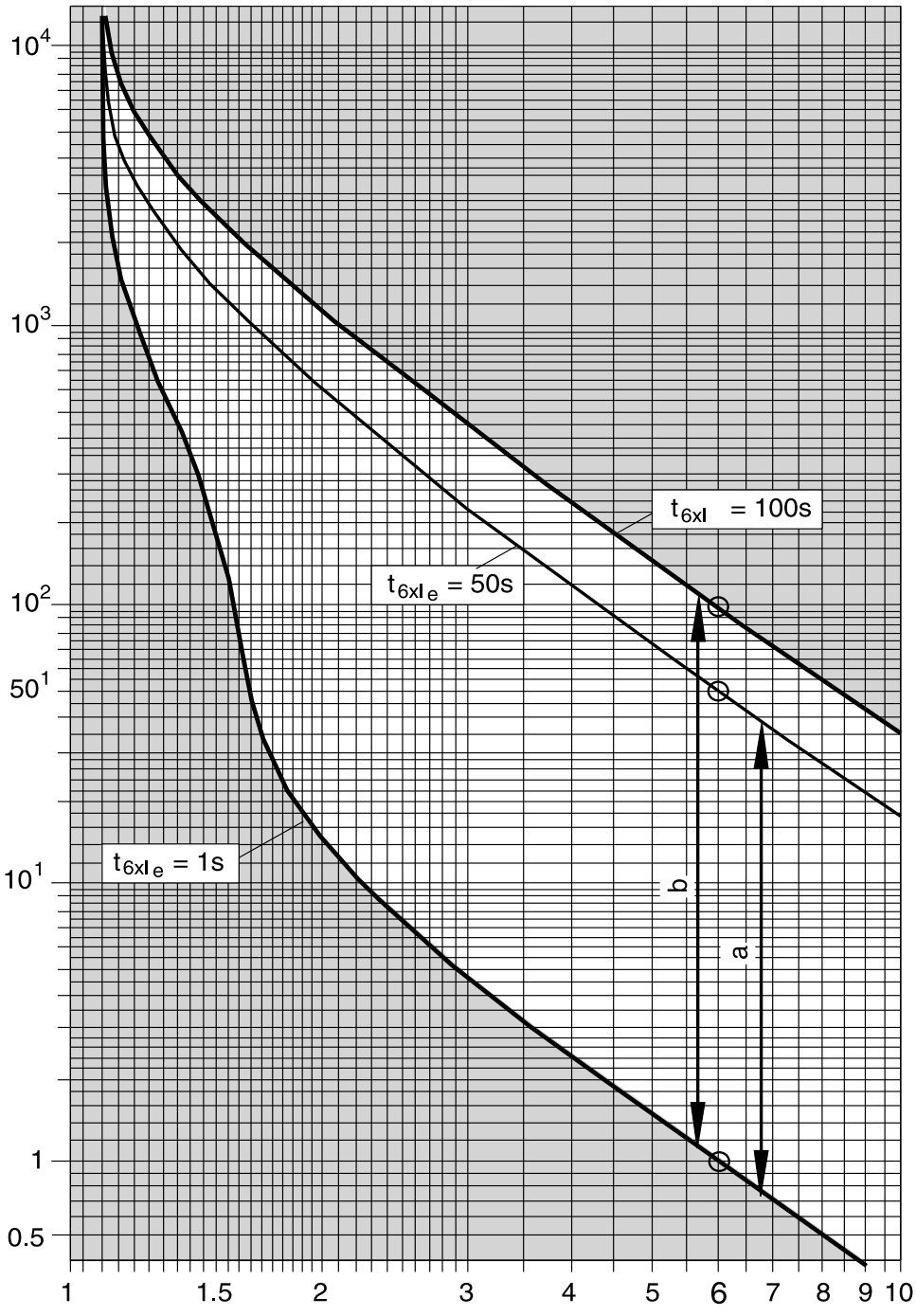


Settings	Display
CONTROL - INPUT #1 ON	I MOTOR < 20 % Ie
SPEED SWITCH ON	• Motor switched on • Motor current < 20 % I_e

If motors have an operational ideling current of less than 20 % I_e, then the information "motor switched on" must be fed with an auxiliary contact of the contactor into the control input #1.

9.12 Time / Current Characteristic of CET 4

Figure 9.13



a: Setting range for UL / CSA applications
b: Setting range for IEC applications

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